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ORIGINAL ARTICLES.

An Upper Carboniferous Fauna from the Amotape Mountains, North-Western Peru.

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(Continued from p. 234.)

(PLATES X–XII.)

FAMILY PLEUROPHORIDAE (*contd.*).

Genus SPHENOTUS Hall.

Sphenotus (?) sp. ind.

(Pl. X, Fig. 1.)

THERE are two specimens, both exfoliated, which seem to be co-specific, and to belong to *Sphenotus*. The larger one is the worse preserved of the two, but the other shows some distortion by pressure; it retains the right valve, which however has its characters very much obscured. A third crushed and exfoliated individual from Gramadal Quebrada may also belong to the species.

Diagnosis.—The shell is transversely elongate, the length being equal to twice the greatest height, which is below the umbones. The inflation is fairly low. The umbones are small, low, and situated in the anterior half of the shell, about one-quarter of the length of the valve from the anterior end. The hinge-line is long and straight: the anterior and posterior margins are evenly rounded, merging gradually into both the dorsal and ventral borders. The latter is nearly straight, and practically parallel to the dorsal margin. The post-umbonal ridge is fairly well-defined and rounded: the dorsal slope is very gently curved, and appears to be traversed longitudinally by a very shallow median furrow. There is some evidence for believing that an extremely faint, broad sinus runs from the umbo to the centre of the ventral margin. The lunule and escutcheon are indeterminate. The ornamentation consists of numerous, closely arranged, fine concentric striae, and of more widely disposed coarser growth-lines.

Remarks.—The characters that can be determined seem to place this species in *Sphenotus*. It is rather similar to the Arkansan form described by Girty (**11**,[1] p. 80, pl. xii, fig. 6) as *Sphenotus* ? sp., though differing in its proportions and in its sculpture.

Localities.—Junction of Sullana Road and Pariñas Quebrada; Sullana Road and "Ammonite" Valley (1½ miles south of El Muerto); probably also from Gramadal Quebrada (east limb of fold) about 3 miles from its junction with the Pariñas Quebrada.

FAMILY MYTILIDAE.

Genus Modiola Lamarck.

Modiola ? sp. ind.

There occurs, among the Gramadal Quebrada specimens, one example of what appears to be a *Modiola*. It lacks the anterior part of each valve. The parts preserved, however, strongly suggest that this transversely elongate shell, inclined downwards in its posterior end, and ornamented with fine concentric striae, belongs to the *Mytilidae*, and probably to *Modiola*.

Locality.—Gramadal Quebrada (east limb of fold) about 3 miles from its junction with the Pariñas Quebrada.

CEPHALOPODA.

NAUTILOIDEA.

FAMILY ORTHOCERATIDAE.

Genus Orthoceras Breyn.

Orthoceras carbonarium (Smith).

(Pl. X, Figs. 3, 3*a*.)

1903. *Bactrites carbonarius*, J. P. Smith, U.S.G.S. Monograph xlii, pp. 31–2, pl. vi, figs. 9–11.
1909. *Bactrites* (?) *carbonarius*, G. H. Girty, U.S.G.S. Bull. 377, p. 51.
1911. *Bactrites carbonarius*, G. H. Girty, U.S.G.S. Bull. 439, p. 96, pl, xiii, figs. 3–5.

Diagnosis.—A fragment of one specimen, an internal cast, occurs which may be referred to Smith's species. It is straight, and but slightly tapering posteriorly, with the septa convex backwards. The suture line is not quite horizontal, but appears to fall very slightly on the ventral side. The siphuncle is marginal, but comparatively stout, with the septal necks retrosiphonate. There is no remnant of the ornamentation preserved.

Remarks.—Smith referred his species to *Bactrites*, but the siphuncle is rather stouter than is typical of the Ammonoidea. The position of the siphuncle is variable in *Orthoceras*, and, though only rarely does it become actually marginal, it may attain that position. The other characters, particularly the nature of the siphuncle itself, indicate the relations of the present species with the Nautiloidea and not with the Ammonoidea.

Locality.—Goniatite Bed, Pariñas Quebrada.

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[1] The figures in heavy type refer to the bibliography at the end.

Orthoceras sp.

(Pl. X, Figs. 4, 4*a*.)

In the collection is one fragment of a cast of an orthoceratid shell, part of a single chamber.

The siphuncle is not very large and is excentric, being placed at a distance of about one-fourth of the diameter from the ventral edge. Nothing is known of the ornamentation.

Remarks.—The fragment is so small that comparison with other species is of no value.

Locality.—Goniatite Bed, Pariñas Quebrada.

FAMILY SOLENOCHEILIDAE.

Genus SOLENOCHEILUS Meek and Worthen.

Solenocheilus ? *australis* sp. nov.

(Pl. X, Fig. 2.)

There are two fragments which may be referred to *Solenocheilus*. One is part of a medium sized whorl, and the other represents younger stages of a form which almost certainly belongs to the same species.

Diagnosis.—The larger specimen has low broad whorls, increasing fairly rapidly in size. The venter is broad and gently convex, and the sides rather short. The umbilicus appears to have been small, and the umbilical shoulders rounded. The septa are fairly close together, with the suture line only slightly undulating—there is a very small saddle on the umbilical shoulders, with a broad low one on the venter.

The smaller specimen differs from the foregoing in being somewhat narrower, with a more convex venter, but these differences are probably due to its being at an earlier stage of growth than the other.

Remarks.—The configuration of the whorls and the nature of the suture seem to place the above species in *Solenocheilus*. The whorls are more depressed than the North American Lower Carboniferous species,[1] while the European forms, e.g. those described by d'Eichwald (**36**), Tzwetaev (**56**), and Foord and Crick (**38**), are quite distinct.

Locality.—Goniatite Bed, Pariñas Quebrada.

AMMONOIDEA.

FAMILY PRONORITIDAE.

Genus PRONORITES Mojsisovics.

Pronorites ? *peruvianus* sp. nov.

(Pl. X, Figs. 5, 5*a*.)

It is unfortunate that there is only one specimen of this species present in the collection. It lacks the venter, so that the generic reference cannot be made with absolute certainty.

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[1] For references see **58**.

Diagnosis.—The total size of the shell cannot be determined, but it was certainly of at least medium size. The whorls are high, and appear to have almost flat sides. The umbilicus is small. The umbilical shoulder is rapidly rounded, and the umbilical slope short.

The suture line is not complete, but five complete lobes and part of a sixth are preserved on the sides of the whorl. They are pointed posteriorly and constricted near the exterior end, and diminish in size quite regularly towards the umbilicus. A small lobe occurs on the umbilical shoulder, and the last visible lies on the umbilical slope. The saddles are linguiform. The parts of the suture on the venter and dorsum are unknown.

Remarks.—This species appears to belong to *Pronorites* Mojs. rather than to one of the genera of the Prolecanitidae related to *Daraelites*, which is recorded from the Lower Permian by Gemmellaro (**40**) and Böse (**34**). In the absence of the venter, however, the possibility of the species belonging to the Prolecanitidae cannot be completely ignored.

Of the species belonging to *Pronorites*, *P. cyclolobus* Phill. sp. (**48**, p. 237, pl. xx., figs. 40–2), and especially the variety *uralensis* Karp. (**44**, pp. 8–11, pl. i, figs. 4*a*–*n*), are nearest in the character of their suture lines to the Peruvian species. The latter has more lobes than has the first named, thus resembling Karpinsky's variety, in which the saddles, however, tend to be more rounded and somewhat broader than in *P. peruvianus*. The suture of *P. cyclolobus* var. *arkansasensis* Smith (**52**, pp. 43–6, pl. xii, figs. 12–15) is also very similar; *P. timorensis* Haniel (**53**, pp. 13, 14, pl. x, figs. 1–15) may be compared as well, but the saddles of its suture line are much narrower. The similarity between the suture lines of all these species is much closer than it is between those of *P. peruvianus*, on the one hand, and those of *P. postcarbonarius* Karp. (**44**), *P. praepermicus* Karp. (**44**), *P. phillipsi* Karp. (**44**, p. 4, footnote 2; **49**, pl. li, figs. 235*a*, *f*, *g*), *P. barroisi* Karp. (**44**, p. 11, fig. 10), *P. siebenthali* Smith (**52**, p. 47, pl. xi, figs. 5–7), and *P. mixolobus* Phill. sp. (**48**, p. 237, pl. xx, figs. 43–7) on the other. The form referred to *Pronorites* ?? sp. ind. by Girty (**12**, pp. 247, 248, pl. xxxiv, figs. 5–5*c*) is quite distinct.

Locality.—Goniatite Bed, Pariñas Quebrada.

FAMILY GLYPHIOCERATIDAE.

Genus Gastrioceras Hyatt.

The generic term *Gastrioceras* should be restricted to forms akin to *G. listeri* Martin sp., the species first mentioned by Hyatt (**43**, p. 327) and therefore taken as the genotype, i.e. to forms with open umbilicus, whorls with trapezoidal cross-sections, with umbilical tubercles, and with eight lobes in the suture line, the external lobe being divided by a prominent siphonal saddle. The number of such species is not very large. There have been included in the genus, however, numerous species differing very much from *G. listeri.* They have little in common with that species other than a similar suture line. In configuration they are very different—the whorl shape and umbilical tubercles are lacking. These forms are not derived from *G. listeri* but from species of *Glyphioceras.* Between them and the typical members of that genus gradations often occur, rendering it difficult sometimes to separate them from *Glyphioceras.*

The species described below, and many of the North American forms, belong to this group with *Glyphioceras* ancestors, and not to the typical *Gastrioceras* group of goniatites. The latter term, however, is employed in conformity with conventional usage, but it does not imply that the species are derived from *G. listeri.*

Gastrioceras amotapense sp. nov.

(Pl. X, Figs. 6, 6*a* ; Pl. XI, Fig. 1 ; Pl. XII, Fig. 1.)

There are several representatives, all casts, of this species, the most abundant Cephalopod present. Some of the specimens are only fragments, but two, though small, show several whorls, while a third larger specimen is fairly complete.

Diagnosis.—The shell attains a large size ; the whorls are moderately inflated, depressed, with a lunate cross-section in the young stages, and are indented to an amount equal to about two-thirds of their height by the preceding whorls ; the venter and sides are broadly rounded, but the latter tend to become flatter in the adult. The umbilical shoulder in young specimens is rounded, and the umbilical slope nearly flat and rapidly descending, but in larger specimens the former is much more rapidly rounded, though not quite sharp, and the umbilical slope is flat. There is no evidence of the presence of tubercles along the umbilical shoulder. The umbilicus is fairly wide and deep (apparently slightly larger in adult specimens), and exposes, in even relatively small examples, four or five whorls.

There are some twenty septa to each whorl. The suture line (Fig. 1) is typically gastrioceratid. The median saddle is large and prominent, and equal to three-fifths of the length of the external lobe. Each half of the latter is hastate and acute posteriorly. The first lateral lobe is similar in shape to this, but is broader. The second lateral lobe is wide, and V-shaped, the apex of the V occurring at about one-quarter of the depth of the umbilical slope from the umbilical shoulder. The three internal lobes are long, narrow, hastate, and slightly constricted anterior to their mid-length : the anti-siphonal lobe is a little longer and narrower than the other two. The external saddle is rounded, tongue-shaped, and slightly constricted near the middle : it is narrower than the first lateral lobe. The first lateral saddle is broad, but shorter than the external saddle. Posteriorly the two bounding sides are inclined widely to one another, but anteriorly the saddle is constricted and the part in front of this is short and rounded. The pair of internal saddles flanking the anti-siphonal lobe are long and tongue-shaped with a shallow constriction near the middle: the pair flanking the outer internal lobes are wide, and rounded-quadrate in shape.

There are six sigmoidal constrictions to each whorl: on the younger whorls they are well-defined, but become much more obscure on the adult whorls.

The holotype has only a fragment of the body chamber preserved, commencing at a diameter of 103 mms.; its complete extent and the nature of the aperture are unknown. The ornamentation is also not preserved.

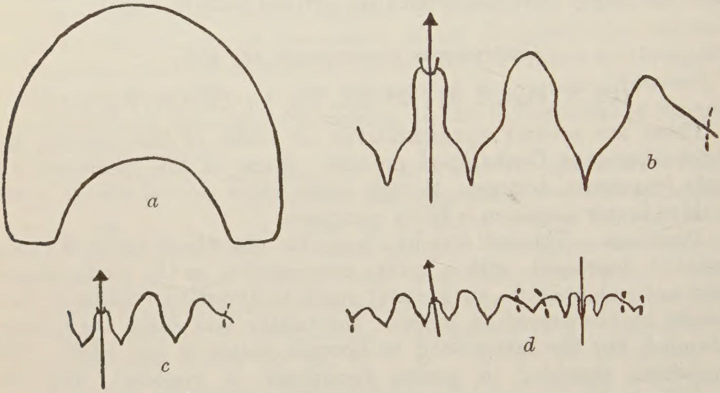

FIG. 1.—*Gastrioceras amotapense* sp. nov. *a* = Outline of the transverse section of an outer whorl of the specimen figured on Pl. XII, Fig. 1; *b* = external part of the suture line of the holotype at X (Pl. XI, Fig. 1); *c* and *d* = suture lines at *A* and *B* respectively of the specimen figured on Plate X, Fig. 6. All natural size.

Dimensions [1] (in mms.) :—

Holotype.[2]	85·0 (100)	24·0 (28)	? 36·0 (42) [3]	34·5 (40)
Specimen 2.	37·0 (100)	11·0 (29)	17·5 (47)	13·0 (35)
„ 3.	27·5 (100)	7·0 (25)	12·3 (44)	10·3 (37)
„ 4.	?	17·5 (29)	27·0 (45) [4]	?
„ 5.	?	21·0 (26)	36·0 (45) [4]	?
„ 6.	?	11·0 (22)	23·0 (46) [4]	?
„ 7.	?	21·0 (27)	35·0 (45) [4]	?
„ 8.	53·5 (100)	? 13·0 (24) [3]	? 26·5 (49) [3]	? 21·0 (39) [3]

[1] The columns of measurements are arranged in the order conventionally used for Ammonoid dimensions—the figures in parenthesis represent those dimensions calculated as percentages of the diameter at which they are taken.

[2] The measurements for this specimen were taken at a position situated at about one-quarter of a whorl before the last septum, as anteriorly it is somewhat crushed.

[3] These measurements are approximate.

[4] The percentages calculated for these heights are made by assuming those for the widths to be as stated.

Remarks.—This species appears to belong to the group of *Gastrioceras globulosum* Meek and Worthen (**45**, p. 390, pl. xxx, figs. 2*a–c*), in the sense used by Smith (**53**, p. 27), and not to that of *G. listeri* (Martin), since it seems to lack the strong umbilical nodes of the latter group. Besides differing in this respect from *G. listeri* (**48**, p. 235, pl. xx, fig. 1 ; **54**, pl. 501, fig. 1 ; **39**, pp. 233–6, figs. 111*a–c*) the typical species of *Gastrioceras* (v. sup.), and from *G. marianum* M.V.K. sp. (**47**, p. 369, pl. xxvii, figs. 2*a–c*), the new Peruvian form shows differences in its hastate lobes and more linguiform saddles, and in its higher whorls. In its suture line *G. amotapense* very much resembles *Girtyites jossae* M.V.K. sp. (**47**, pp. 371, 372, pl. xxvi, fig. 2 ; **57**, p. 160), but it is less evolute than that species and lacks its umbilical tubercles. Roemer figures a form as *G. listeri* but it seems to possess a non-tuberculate umbilicus and to have a somewhat different configuration (**51**, pl. viii, figs. 12, 13) : it is different from *G. amotapense.*

Turning to the group of *G. globulosum* M. and W. itself, the great width of that species at once separates it from the Peruvian form, while its suture also shows differences (loc. sup. cit. ; **52**, p. 89, pl. xxi, figs. 7–9). Similarly *G. excelsum* Meek sp. (**52**, pp. 88, 89, pl. xvi, figs. 2*a*, *b*, pls. xxviii, xxix) and *G. hanieli* Smith (**53**, pp. 28, 29, pl. ix, figs. 1–6) are easily distinguished though in these cases the suture lines are much more like those of the South American form. *G. illinoisense* Miller and Gurley (**52**, p. 91, pl. xvii, figs. 6–8), *G. kansasense* M. and G. (**52**, pp. 91, 92, pl. xvii, figs. 9–11), *G. nolinense* Cox sp. (**52**, pp. 95, 96, pl. v, figs. 8–10), and *G. hyattianum* Girty (**12**, pp. 254–6, pl. xxxii, figs. 6, 6*a*, pl. xxxiii, figs. 1–4*d*), all have similar suture lines to *G. amotapense,* though differing in certain respects, and, with the exception of *G. nolinense*, have somewhat analogous configurations, especially when compared with the adult forms of the Amotape species. Characteristic differences in the latter, however, are the relatively broad halves of the external lobe, the linguiform external saddle and the long acute termination of the first lateral lobe.

Comparison, too, may be made between *G. amotapense* and *G. suessi* Karp. (**44**, pp. 52–4, pl. iii, figs. 3*a–g*). The whorls in the former are more depressed especially in the young stages, but the sutural similarities are very close. The suture of *Gastrioceras* sp. ind. Karp. (ibid., pp. 54, 55, fig. 29, and pl. iii, figs. 2*a–c*) is also similar, but the configuration is rather different. When the faunas described by Gemmellaro (**40**) from Sicily and by Böse (**34**) from Texas are considered no species with strong affinities can be found.

Rather than with such Permian forms, but with Lower Uralian forms like those of North America, are the species co-existing in time with *G. amotapense* to be found.

Locality.—Goniatite Bed, Pariñas Quebrada.

Gastrioceras pacificum sp. nov.

(Pl. XII, Figs. 2, 2*a*.)

The material on which this species is based is a single specimen.

Diagnosis.—The shell is moderately large, the whorls lofty and helmet-shaped in cross-section. The venter is rounded and the sides nearly flat. The umbilical shoulder is rapidly rounded, while the umbilical slope is slightly convex and nearly vertical. The umbilicus is not very wide, but fairly deep.

The suture line (Fig. 2) is curious in that, though possessing eight lobes and thereby gastrioceratid, five of the lobes are external, none occurring on the umbilical slope. The broad external lobe is divided by a fairly high but rather narrow median saddle into two halves, each of which is hastate ; the posterior part narrows rapidly, and is produced and tapering, while anteriorly the half-lobes are slightly constricted. The first lateral lobe is similar in shape to the two components of the external lobe, but is rather broader than they are. The second lateral lobe is well-developed and forms a narrow V posteriorly—anteriorly its margin on the side towards the siphuncle is fairly long and slightly curved ; the other margin is short and straight, and anteriorly curves rapidly into the second lateral saddle.

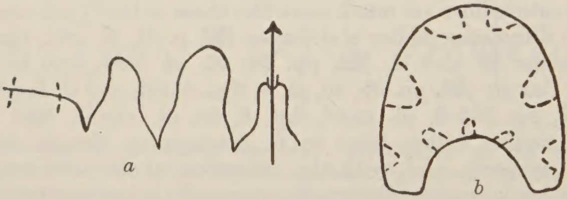

Fig. 2.—*Gastrioceras pacificum* sp. nov. *a* = External part of the suture line of the holotype; *b* = outline of the transverse section of the whorl of the holotype at a diameter of 67·0 mm. Both natural size.

The external saddle is tongue-shaped, with a very slight constriction near the middle of its length, and is broader than either of the lobes bordering it. The first lateral saddle is also linguiform but anteriorly its axis is slightly bent away from the siphuncle. The second lateral saddle is flattened at its front margin, and extends across the umbilical shoulder and umbilical slope : from the position (Fig. 2*b*) of the three internal lobes which lie near the centre of the dorsum, this second lateral saddle is very broad. The shape of the internal part of the suture cannot be determined. On the half-whorl preserved there are two faint slightly sigmoidal constrictions.

The ornamentation of a part of the valve is preserved as an external cast : it consists of numerous, fine, transverse and spiral striae. The former curve slightly forwards near the mid-height of the valve, and then rapidly backwards as they pass on to the ventral surface. The latter are missing over most of the lateral part and are first developed near to where the curve of the venter commences; they number about two to a millimetre.

Dimensions in mm. (of holotype) :—

67·0 (100)	17·5 (26)	23·0 (34)	22·0 (33)

Remarks.—This species is remarkable for the character of the suture line. At first sight it appears to belong to *Paralegoceras*, but it lacks the extra pair of lobes on the umbilical slope, so that only eight lobes altogether are present in the complete suture. In these characters it compares with *G* ? *russiense* Tzwetaev (**55**, pp. 42–4, pl. vi, figs. 30–2), but it differs in the broader whorls of that species, and the sutures, though very similar, show certain small but distinct differences in the shapes of the lobes.

Allowing for the extra lobe in that species, the suture lines of *Paralegoceras sundaicum* Haniel (**42**, p. 58, pl. xlviii, fig. 3; **53**, pp. 34–6, pl. i, figs. 1, 2, pl. ii, figs. 1–22) and of several of the species of *Paralegoceras* described by Smith from Timor have considerable resemblances to the above species, closer indeed than that of *P. tschernyschewi* Karp. (**44**, pp. 62, 63, pl. iii, figs. 1*a*–*c*), a form which Smith also records. *P. sundaicum* and *P. gigas* Smith in addition have somewhat similar configurations. The suture line of the Australian Upper Carboniferous *P. jacksoni* Eth. fil. sp.[1] (**37**, p. 36, pl. ix, figs. 1–3; **35**, pp. 249–52, pls. xi–xiii) may also be compared with that of *G. pacificum* [2]—the pair of extra lobes in the Australian species are very small.

Locality.—Goniatite Bed, Pariñas Quebrada.

Gastrioceras browni sp. nov.

(Pl. XII, Figs. 3, 3*a*.)

There are two nearly complete individuals of this species.

Diagnosis.—The shell is of medium size, involute, the whorls increasing fairly rapidly in height. The venter is rapidly rounded and the sides somewhat curving. The umbilical shoulder and the umbilical slope are both rounded. The suture line (Fig. 3) is gastrioceratid: the median saddle is relatively high; each half of the external lobe as well as the first lateral lobe is hastate; the external saddle appears linguiform, and the first lateral saddle broad and rounded anteriorly; there seems to be a suspensive lobe on the umbilical shoulder, though this can but be inferred.

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[1] A paper dealing with this species is to be published elsewhere in the immediate future.

[2] Since the above was in manuscript a fragment of a Goniatite has been described by E. W. Berry from the Amotape Mountains, and made the holotype of *P. peruvianum* Berry (*Amer. Journ. Sci.*, ser. v, vol. xv, No. 86, pp. 151–3, Feb., 1928). His species may be the same as the one described above; the part of the suture line figured is almost identical, but the single specimen he had, together with the figure he gives of its outline, does not render its identification at all certain with *G. pacificum*.

The body-chamber extends for at least a distance equal to seven eighths of a whorl. There is a well-defined sigmoidal constriction coinciding almost with the last suture line and a much fainter though quite distinct one anterior to it, which must be very near to the aperture : between these two there are what appear to be two other obscure constrictions. There is no trace of the surface ornamentation.

Dimensions in mm. :—

Holotype[1]	56·0 (100)	26·5 (47)	? 21·0 (37)	12·5 (22)
Specimen 2	60·0 (100)	? 25·0 (41)	? 25·0 (41)	?

Remarks.—This species rather strongly recalls certain species of *Glyphioceras*. Among members of its own genus *G. federowi* Karp. (**44**, pp. 56–8, pl. iv, figs. 1*a*–*p*) bears a close resemblance in suture and configuration, but the umbilicus in that species is a little larger and the whorls somewhat narrower. *G. abichianum* Möller sp. (**46**, p. 229 ; **33**, p. 219, pl. xviii, figs. 5*a*–*d*), previously referred to *Goniatites striatus* by Abich (**32**, pl. i, figs. 1–3, pl. xi, fig. 2), is also similar, but, among other differences, the increase in width of the whorls in that species is apparently more rapid.

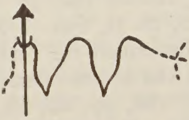

FIG. 3.—*Gastrioceras browni* sp. nov. Septal suture of the holotype. Natural size.

Locality.—Goniatite Bed, Pariñas Quebrada.

Gastrioceras ? *parinasense* sp. nov.

(Pl. X, Figs. 7, 7*a*.)

A single internal cast (half a whorl), quite distinct from those described above, is the sole representative of a further species.

Diagnosis.—The part preserved is that of a small whorl, semilunate in cross-section, its height equal to only about one-quarter of the width. The venter is gently rounded, and the sides very low. The umbilical shoulder is angular, while the flattened umbilical slope is inclined at an angle of about 60° to the horizontal. The umbilicus is wide, and apparently deep. The nature of the suture line and the character of the ornamentation are unknown, though the cast has no evidence of tubercles along the umbilical shoulder. On the half of the whorl there is one well-defined slightly curving constriction.

Dimensions in mm. (of holotype) :—

28·0 (100)	5·5 (19)	18·0 (64)	13·0 (46)

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[1] These measurements are taken at a position situated at about one-half of a whorl anterior to the last septum.

Remarks.—This species is referred to *Gastrioceras* from those characters which can be observed. It is quite different from those described above.

G. kingi Hall and Whitfield sp. (**41**, p. 299, pl. vi, figs. 9–14), *G. subcavum* M. and G. sp. (**52**, p. 97, pl. xvii, figs. 15–17), *G. welleri* Smith (**52**, p. 98, pl. xxiv, figs. 13–20), and *G. nikitini* Karp. (**44**, pp. 55, 56, pl. iv, fig. 55), all show certain similarities to *G.* ? *parinasense* in configuration. Perhaps, too, may be mentioned *G.* ? *baroghilense* Reed (**50**, pp. 104, 105, pl. x, figs. 8, 8*a*) from the Upper Carboniferous in Chitral, though the resemblance is only remote—the dorsal median depression in that species is very peculiar.

Locality.—Goniatite Bed, Pariñas Quebrada.

Gastrioceras sp.

(Pl. XI, Figs. 2, 2*a*.)

There is one specimen which retains its shell structure.

Diagnosis.—The shell is discoidal, with helmet-shaped whorls: the venter is rounded, and the sides only slightly curved. The umbilicus is small but unfortunately obscured; its shoulder appears to be rounded. The suture line is unknown. The ornamentation consists of closely arranged fine radial striae and of numerous close spiral striae. The former curve markedly anteriorly as they cross the junction of the venter and the sides, and then backwards over the venter. The whole outer surface is covered with fine tubercles at the intersections of the two sets of striae.

Dimensions in mm. :—

43·5 (100)	13·5 (31)	20·5 (47)	11·5 (26)

Remarks.—With its suture line unknown this species can be referred only doubtfully to *Gastrioceras*, though its characters seem to indicate its position in that genus. Although rather similar in shape to *G. pacificum* this species appears to be distinct on account of its narrower umbilicus.

Locality.—Goniatite Bed, Pariñas Quebrada.

EXPLANATION OF PLATES X–XII.

All the figures are of the natural size, except where otherwise stated.

Plate X.

Fig.

1.—*Sphenotus* ? sp. ind. A left valve, × $\frac{4}{3}$. Junction of the Sullana Road, Pariñas Quebrada.

2.—*Solenocheilus* ? *australis* sp. nov., holotype, × $\frac{4}{3}$. Goniatite Bed, Pariñas Quebrada.

3.—*Orthoceras carbonarium* (Smith). Dorsal view, × $\frac{4}{3}$. The specimen is inverted. Same locality.

3*a*.—Do. Posterior view showing marginal siphuncle, × $\frac{4}{3}$.

4.—*Orthoceras* sp. Posterior view showing siphuncle, × 2. Same locality.

4*a*.—Do. Side view, × 2.

FIG.
5.—*Pronorites* (?) *peruvianus* sp. nov., holotype. View of left side, × $\frac{4}{3}$. Same locality.
5*a*.—Do. Right side, × $\frac{4}{3}$.
6.—*Gastrioceras amotapense* sp. nov. A small specimen, × $\frac{4}{3}$. Same locality.
6*a*.—Do. Outline of section of whorl at C, × $\frac{4}{3}$.
7.—*G.* (?) *parinasense*, sp. nov., holotype. Anterior view of specimen, × $\frac{4}{3}$. Same locality.
7*a*.—Do. View of right side, × $\frac{4}{3}$.

PLATE XI.

FIG.
1.—*G. amotapense* sp. nov., holotype. Same locality.
2.—*Gastrioceras* ? sp. Same locality.
2*a*.—Do. Anterior view.

PLATE XII.

FIG.
1.—*Gastrioceras amotapense* sp. nov. Interior whorls of a large specimen. Same locality.
2.—*G. pacificum* sp. nov., holotype. Same locality.
2*a*.—Do. External cast of part of the ornamentation, × $\frac{4}{3}$.
3.—*G. browni* sp. nov., holotype. Same locality.
3*a*.—Do. Outline of anterior view, partly restored ; very slightly enlarged.

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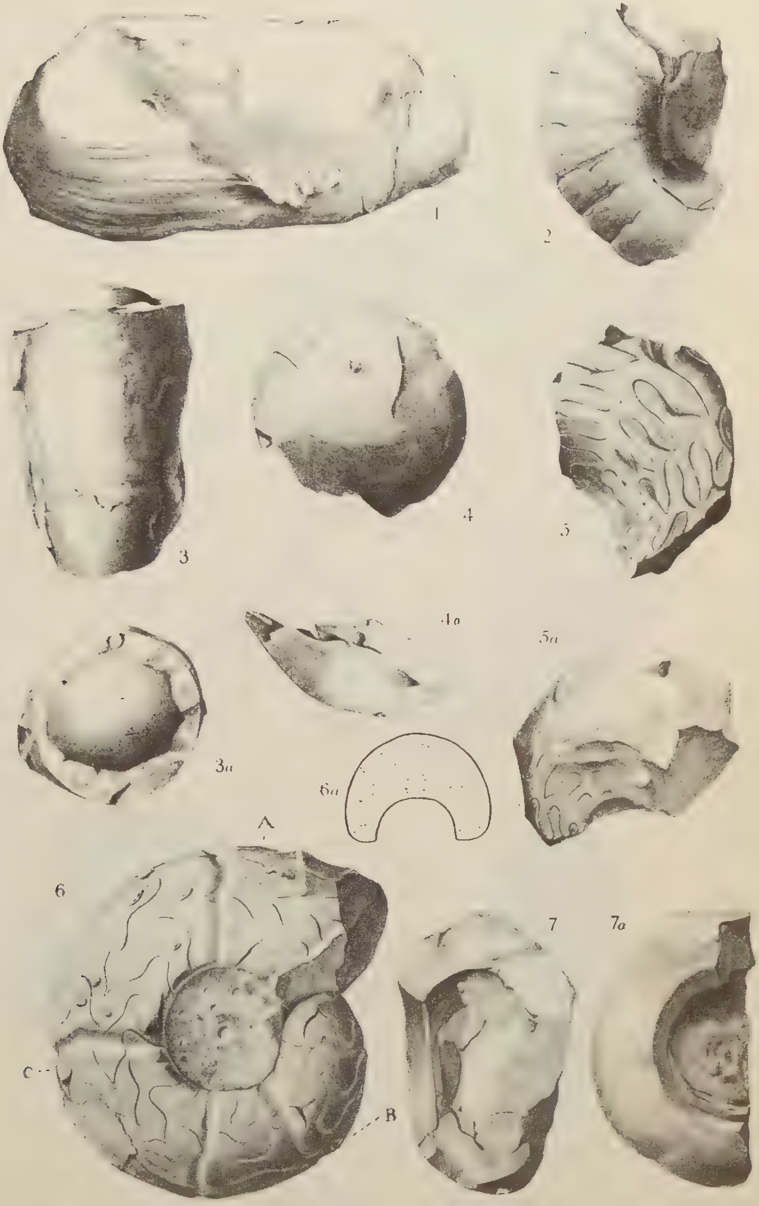
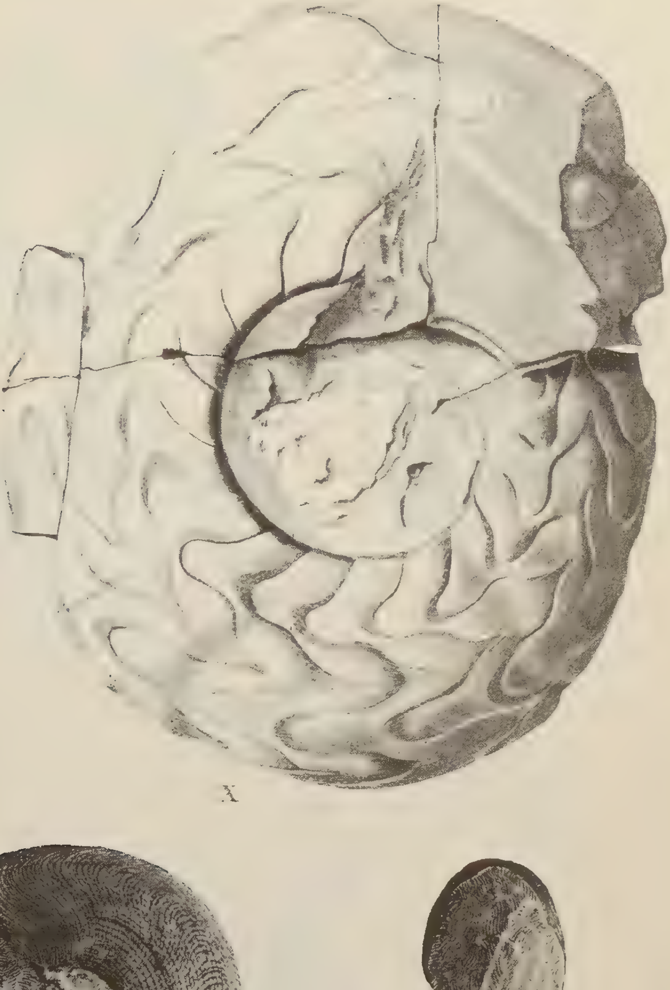


C.B.B. del.

PERUVIAN CARBONIFEROUS FOSSILS.

[*To face p. 300.*



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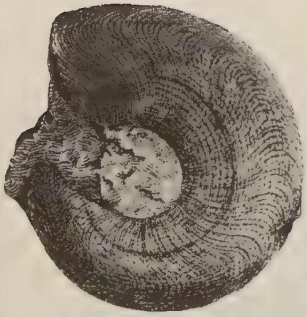

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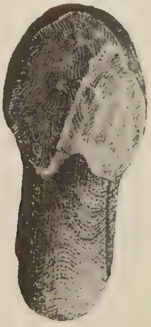

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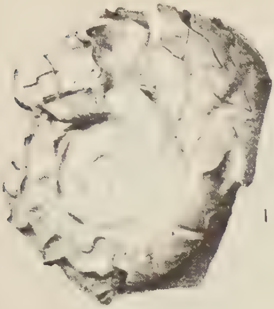
PERUVIAN CARBONIFEROUS CEPHALOPODA.



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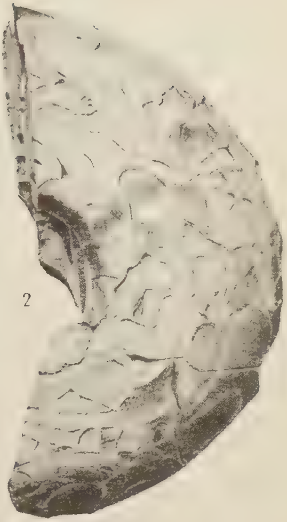

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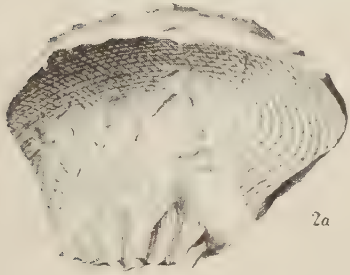

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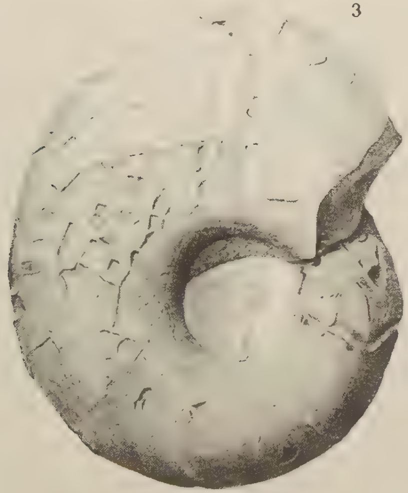

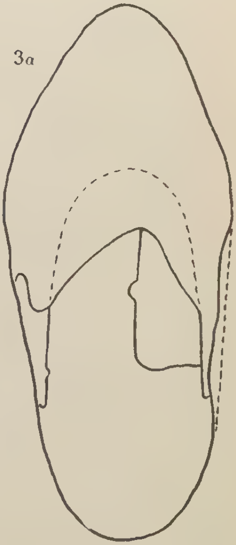

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(*To be continued.*)

"Washouts" in the Estuarine Series of Yorkshire.

By Maurice Black, B.A., F.G.S., Trinity College, Cambridge.

THE Middle Jurassic of Yorkshire consists of non-marine strata, known collectively as the Estuarine Series, and several intercalated marine bands. The non-marine beds have the characteristics of deposits formed as a delta rather than in an estuary, and are, in fact, strongly reminiscent of the Coal Measures in their general appearance. In the coast section, where they are admirably exposed, these beds show abrupt structural and lithological changes, which are usually due to the presence of false bedded sediments replacing the normally parallel bedded strata. Thick wedges of sandstone replacing the Dogger, and sometimes part of the Upper Lias too, have been described by Dr. Rastall[1] and Fox-Strangways.[2] They are particularly noticeable when they interrupt the top seam (i.e. the Dogger) in the iron mines, where they are called "freestone baulks" by the miners.[3] The same phenomenon is better known in the Coal Measures, where the term "washout" is used for a mass of sandstone suddenly replacing coal. Although there are several objections to the term "washout", it is used here since it has become so well established in Coal Measure geology.

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[1] R. H. Rastall, "The Blea Wyke Beds and Dogger in North-East Yorkshire": *Q.J.G.S.*, vol. lxi, 1905, pp. 441, 450, 452, 456, and figs. 1 and 2.

[2] C. Fox-Strangways, *The Jurassic Rocks of Yorkshire*, 1892, pp. 154, 159, 162, 163, and fig. 9.

[3] C. Fox-Strangways, *The Jurassic Rocks of Yorkshire*, p. 162.

Like the Carboniferous washouts, these masses of sandstone are lenticular in section, and may readily be shown to fill channels eroded in the level-bedded strata below. They represent, in fact, the courses of distributaries which flowed over the surface of the Middle Jurassic delta of North-East Yorkshire.

The streams which occupied these channels seem to have been capable at times of effecting considerable erosion, and such erosion seems to have played an important part in determining the structure at the base of the Lower Estuarine Series. In many cases, however, the channels seem to have been formed as a normal result of continuous delta sedimentation, and are not indicative of widespread erosion.

Washouts are of unequal importance throughout the rest of the Estuarine Series; in the Lower Estuarine Series channels appear at levels other than the base—for example, there is a well-exposed washout at Iron Scar near Cloughton, which just fails to cut down to the Eller Beck Bed. In the Middle Estuarine Series there is a possible example of a channel at Gristhorpe cutting into the Millepore bed, but such structures are not at all common in this series.

In the Upper Estuarine Series the channels become of greater importance again. Exposures of washouts are extremely abundant in the coast section near the base of the Level Bedded division of this series, but the evidence is not quite sufficient to say whether they are separate washouts representing a period of erosion, or, as seems more probable, they are merely repeated sections of one or two channels whose meanders are cut several times by the present coast line. The inland sections show channels at other levels.

LITHOLOGY AND STRUCTURE.

The only section of the Estuarine Series which is suitable for the investigation of the structures of washouts is that of the coast, where the beds are almost horizontal with a very slight dip to the south. This makes the section peculiarly favourable for the purpose. Large channels (which sometimes run parallel to the coast, and may then be quite clearly seen to meander), and smaller ones which accompany them, are cut by the coast and may be examined for considerable distances, either in clean-cut sections in the cliff, or dissected by erosion on the shore.

The most characteristic lithological type associated with washout erosion is a contemporaneous conglomerate consisting of fragments of the rocks through which the channel has been cut. The boulders most commonly found are of sandstone, shale, banded or laminated silt, clay-ironstone, and coaly material, chiefly fusain. The matrix is variable, and may be anything from a sandy silt to a coarse grit (in some of the larger channels), whilst the size of the boulders and their degree of rounding also shows a considerable variation; quite frequently they are entirely angular, but there is every gradation between these and well-rounded ones. The boulders may considerably exceed 1 foot in diameter, but rarely average more than about 6 inches.

It seems most probable that the blocks of large size which are found in lenticular beds in the bottoms of washout channels have been derived directly from the undercutting of the banks of the channel, which may have consisted of shales and sandstones in a more or less solidified condition. The extent to which the level-bedded sediments were solidified before erosion is rather doubtful, but it may be pointed out that in most cases the shale and mud were hard enough to form sharply angular fragments, and the laminated sandstones and silts were often coherent enough to form flat plates parallel to the lamination. In other cases, blocks of banded and laminated sediments are seen to be crumpled and distorted. In the Lower Estuarine Series clay-ironstone pebbles are frequent, and often form conglomeratic bands by themselves. The pebbles might have been derived equally well from beds of Yeovilian or Dogger age as from those of Estuarine age, were it not for the fact that the pebbles in the conglomerate seldom include fragments of fossils. It might be inferred from this that most of the material came from already solidified non-marine beds. In view of our scanty knowledge of the Yeovilian beds of this area, however, this can hardly be more than a matter of speculation. In the washout conglomerates of the Upper Estuarine Series derived fragments of nodules are generally rare, although subsequently formed ironstone nodules are usually present, and the conglomerates may even be bound together by a sideritic cement. It might be suspected from facts of this kind that the time which elapsed between the deposition of the basal beds of the Lower Estuarine Series and their erosion was greater than in the case of the Upper Estuarine Series, but here again judgment must be suspended until more is known about the origin of the pebbles.

The bedding of the sediments in these washouts need hardly be described at length. In a longitudinal section the wedges of sediment which fill the channel have an original dip downstream, which is sometimes fairly constant for short distances. In a cross section (see Figs. 1 and 2) the sandstone and silt are seen to be banked up against each side, and the conglomerates form lenticles on the bottom of the trough and on the sides. Very often the basal layer is either a coarse grit or a grit enclosing a conglomerate, which may consist of ordinary sediments (e.g. Cromer Point, N. of Scarborough), cementstone pebbles, pebbles washed out from another bed and enclosed in a fresh matrix (e.g. East Cliff, Whitby), or pyrite nodules (e.g. Gristhorpe); whether there is a conglomerate or not, the basal layers often contain large logs of wood (East Cliff, Whitby). In some of the smaller channels pebbles of the conglomerate may be matched with sediments in the bank.

The main filling of the channel often takes the form of a massive sandstone, which on erosion breaks into large blocks. Towards the top of the channel the bedding becomes more level, and the sediment more silty and argillaceous, with a strong tendency to develop ironstone nodules. The latest stage is often represented by a bluish grey, peaty silt, with but little bedding, and sometimes with plant remains and rootlets—apparently formed at a stage when the channel had been silted up and only a few disconnected pools remained.

MINOR DISTURBANCES CONNECTED WITH WASHOUTS IN THE COAST SECTION.

In the geology of the Coal Measures the term "washout" appears to have been used both for true stream channels and for structures of purely tectonic origin; thus the origin of washouts has been a subject of frequent debate. The question at issue is whether the large majority of these structures have a tectonic origin, or whether they represent the courses of streams flowing over the Coal Measure Delta.[1]

The erosion channels of the Yorkshire coast, where any disturbance or dislocation in the strata can be shown to be the result and not the cause of the washouts, offer a particularly favourable opportunity for studying the structure of washouts and their relation to the surrounding strata. In this section distortion of the original structures has been extremely slight, and tectonic displacements are by no means abundant. Normal faults and folds, where they do occur, are easily recognizable, even when they affect false-bedded sandstone. They do not enter into the present discussion, except that they must be recognized in the field and distinguished from the structures described below. Minor disturbances in the bedding of the Estuarine Series are found at various places, and, unlike the ordinary faults, their origin can be definitely connected with the presence of washouts.

At Yons Nab, between Gristhorpe Bay and Cayton Bay, there are vertical beds of sandstone and shale in the cliff, whilst horizontal and undisturbed strata may be seen both above and below them. (See Figs. 3 and 4.) In some cases the vertical strata can be seen to rest upon a surface of sliding, which cuts the beds below abruptly.

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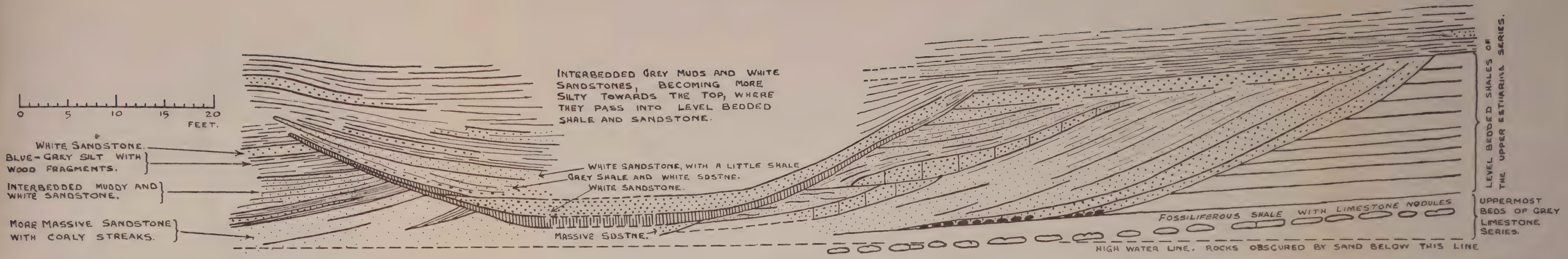
[1] Two important discussions of this and related problems are:—

W. G. Fearnsides, "Some Effects of Earth Movement on the Coal Measures of the Sheffield District": *Trans. Inst. Mining Eng.*, vol. l, 1915, pt. i, pp. 109–25; pt. ii, pp. 573–624.

P. F. Kendall, "The Physiography of the Coal Swamps," Presidential Address to Section C, British Association, Hull, 1922.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FEET.
INTERBEDDED GREY MUDS AND WHITE SANDSTONES, BECOMING MORE SILTY TOWARDS THE TOP, WHERE THEY PASS INTO LEVEL BEDDED SHALE AND SANDSTONE.
WHITE SANDSTONE.
BLUE-GREY SILT WITH WOOD FRAGMENTS.
INTERBEDDED MUDDY AND WHITE SANDSTONE.
MORE MASSIVE SANDSTONE WITH COALY STREAKS.
WHITE SANDSTONE, WITH A LITTLE SHALE
GREY SHALE AND WHITE SDSTNE.
WHITE SANDSTONE.
MASSIVE SDSTNE.
FOSSILIFEROUS SHALE WITH LIMESTONE NODULES
HIGH WATER LINE. ROCKS OBSCURED BY SAND BELOW THIS LINE
LEVEL BEDDED SHALES OF THE UPPER ESTUARINE SERIES.
UPPERMOST BEDS OF GREY LIMESTONE SERIES.

Fig. 1.—Part of a channel on the south-east side of Yons Nab, Gristhorpe, Yorkshire. It has cut through the lowest beds of the Upper Estuarine Series to the Grey Limestone Series below. The deposits in the main washout have been cut at a later stage by a smaller channel (marked out by the bed of shale-conglomerate). The section is obscured by boulder clay to the left, so that only a fraction of the main washout is exposed. The centre of the smaller channel is similarly obscured, and has been left blank in the figure.

INDEX TO LITHOLOGY.

- ⚬ BOULDER CLAY.
- ⁘ SANDSTONE.
- ☰ SHALE.
- ▥ SHALE-CONGLOMERATE.
- ● PYRITES NODULES.
- ⬭ LIMESTONE NODULES.

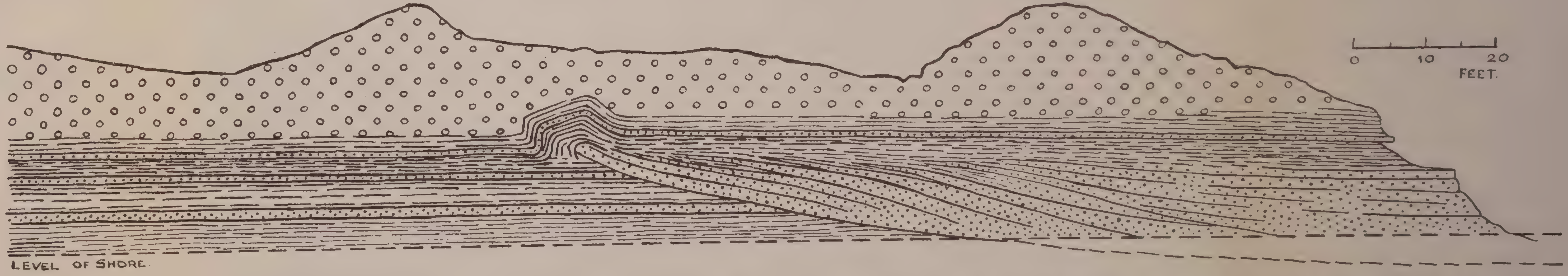

Fig. 2.—Edge of a channel in the cliff section, Scalby Wyke, Yorkshire. The channel is cut in soft shales, and is filled principally by more resistant sandstones. The beds immediately above the edge of the channel are bent into a small anticline.

N.B.—These figures have been drawn from photographs of the sections, and are only roughly to scale.

[To face p. 304.

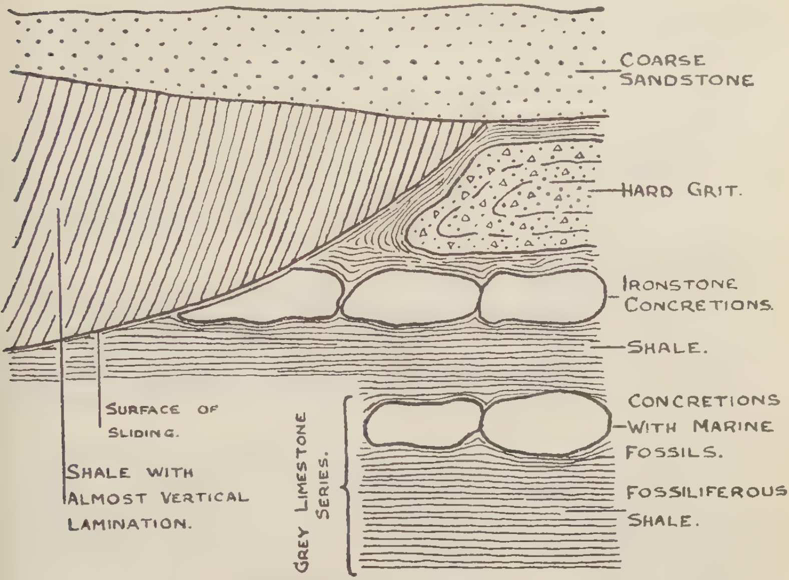

FIG. 3.—Section at Yons Nab showing undisturbed shales of the Grey Limestone Series with a contorted lens of grit above. These beds are replaced to the left by a mass of shales with a very high dip. Height of section about 5 feet.

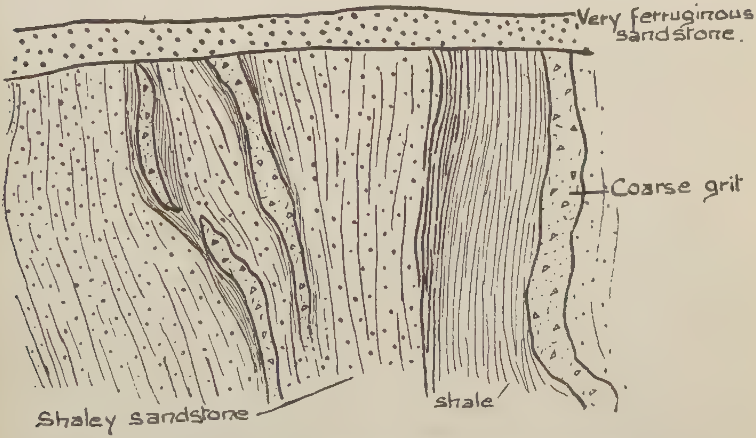

FIG. 4.—Section in the Upper Estuarine Series at Yons Nab showing vertical beds of grit, sandstone, and shale. Height of section about 5 feet.

That the movement which produced this structure took place before the cementation of the sandstone is shown at the section represented in Fig. 3. Here there is a band of grit which is sharply folded, apparently by the same movement. It is now a compact and very hard quartzite, and in its present condition could not possibly have been contorted thus amongst the soft shales in which it is embedded.

At the time when the section shown in Fig. 4 was examined the adjoining parts of the exposure were covered by a slip of boulder clay, but it seems probable that here again the strata rest upon a surface of sliding.

Many of the other structures in this section point to the proximity of a washout and the production of vertical bedding may possibly be attributed to subsidence in the banks, Less than half a mile away a channel which cuts down to the Grey Limestone Series (shown in Fig. 1) emerges from the cliff, giving direct evidence of channel erosion at the level in question.

At the southern edge of the channel containing the sandstone which forms the small reef 700 yards south of Cromer point, there is a small but sharp anticlinal fold of a superficial nature. (See Fig. 2.) This fold is exactly above the place where the sandstone at the margin of the channel dies out, and actually encloses its attenuated edge. The effect of the fold does not extend downwards, and it seems fairly clear that it is due to differential movement produced by the massive wedge of sandstone amongst the shales during settling down and contraction after deposition.

The northern edge of the Cromer Point channel shows a number of miniature step faults with throws of 3 feet or less. They are accompanied by very marked slickensiding on the sandstone which they cut, but their effect dies out rapidly in the overlying shales, and a few feet above there are no signs of a fault at all. These faults also appear to be the result of movements during the settling down of the sediments.

There are two interesting features connected with these faults, which have some bearing on the interpretation of underground sections of Coal Measure washouts.

In the first place, they are near the bank of the channel, where contemporaneous conglomerates of shale and sandstone form a conspicuous deposit. These conglomerates might easily be mistaken for fault breccias, for they are entirely of local rocks. They are, however, clearly sedimentary bands, and furthermore they are cut by the faults, which are thus later than, and not contemporaneous with, the conglomerates. Another point of interest is that the faults run parallel with the edge of the channel, and thus in an underground and restricted section, would resemble minor thrusts, and might be used as evidence that the floor of the washout itself was a thrust.

Thus the evidence of the Yorkshire coast washouts goes to prove that structures simulating those formed as a result of true thrusting movements may be produced by entirely different causes. In a restricted section it may be difficult, in the absence of other evidence, to decide whether the structures have a tectonic origin or not.

The author wishes to express his indebtedness for advice and assistance in the preparation of this paper to Miss Edna Janisch, Mr. T. C. Nicholas, Dr. Hamshaw Thomas, Dr. R. H. Rastall, and Mr. A. G. Brighton.

Notes on the Pleistocene Deposits of the Cambridge District.

By J. E. Marr, Sc.D., F.R.S., and W. B. R. King, O.B.E., M.A.
With a report on the Mollusca by A. S. Kennard, F.G.S., and B. B. Woodward, F.G.S.

ONE of us has described these deposits in two papers read before the Geological Society (*Q.J.G.S.*, vol. lxxv, 1919, p. 204; vol. lxxxii, 1926, p. 101.

In these papers an attempt was made to show, that after a glaciation, aggradation of the valleys occurred in Lower Palaeolithic times, this aggradation being determined by depression which is marked by the marine deposits of March, the Nar Valley, and other localities; that subsequently another glaciation occurred, probably in Mousterian times, and that this was succeeded by erosion in Upper Palaeolithic times.

I. New Records.

Some fresh evidence has been obtained since the publication of the latter of the two papers above-named, which we propose to record.

The discoveries will be taken in order starting in the south. This was the course adopted in the latter of the two papers.

The mollusca found by us at the various localities have been examined by Mr. A. S. Kennard, F.G.S., and Mr. B. B. Woodward, F.G.S., whose report thereon is appended to this paper. We wish to tender our grateful thanks for this most important contribution.

(1) Section in sewage drain along Sedley Taylor Road, 1,000 yards south of the crossing of Hills' Road and the main line near Cambridge station: altitude about 50 ft. (Agricultural Show site of appended report.)

The material thrown out in this cutting was a gravelly loam with much chalky material. Some shells were obtained from it which are recorded in the report appended, where it is stated that this is "probably a late Pleistocene deposit". The significance of this will be discussed later.

(2) *Travellers' Rest Pit.*—Digging has been renewed on the south-eastern face and some interesting discoveries have been made. The exposure shows practically the conditions depicted at the left-hand side of the diagram on page 212 of the *Quarterly Journal of the Geological Society*, vol. lxxv.

The unevenbedded gravel series was in places quite evenly bedded, consisting of alternations of gravel, sand, and fine loam. In two seams of the latter, separated by only an inch or two of gravel, were found the very interesting shells recorded in the report which are there stated to indicate cold conditions. A rubble drift was formerly seen above the unevenbedded gravels, but is not now exposed in the face at present worked. This was deposited under conditions obviously very different from those during the deposition of the shell-bearing loams, the latter being clearly of aquatic origin. Here the unevenbedded gravels are succeeded by a few feet of blue clay with scattered flints, weathering to a chocolate brown, the weathered part becoming very compact and having much stalagmitic deposit in it. It resembles boulder clay except that boulders, if they occur, are sparsely distributed, but it is probable that this clay is the continuation of the clay which contained Chalk boulders and was found in a field 100 yards or so to the north-west. This was mentioned by one of us in the discussion on the paper mentioned above.[1]

There seems no doubt that the clay filling the channels is the decalcified base of this clay. The Upper evenbedded gravels which cut off the tops of the channels was also seen passing over the main mass of this blue clay.

(3) Section in the sewer cutting along Green End Road, 450 yards S. by W. of Milton Road level crossing, Cambridge. (Surface altitude about 35 feet.)

This section showed some 10 to 12 feet of gravel resting on the Gault. The shells were found in several piles of fine loamy gravel which had been thrown out: a few mammalian bones were obtained buried in the uppermost beds of the Gault into which they had worked their way.

The large series of shells recorded in the report indicate that "this deposit is of the same age as the well-known gravel of Barnwell Abbey."

II. Conclusions.

(1) With regard to the shells at Sedley Taylor Road, they would appear to indicate that the depression in which these gravels lie was occupied by the river in late Pleistocene times, that is during a period subsequent to the formation of the *Corbicula*-bearing gravels, and the river was afterwards diverted to its present course to the east of this. This accords with the view expressed by the

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[1] *Q.J.G.S.*, vol. lxxxii, 1926, p. 143.

Geological Surveyors in the *Memoir on the Geology of the District around Cambridge* (page 101). The present surface of these gravels appears to grade with that of the intermediate terrace in the town of Cambridge.

(2) *Travellers' Rest Pit.*—The new discoveries throw light on two important matters. The shells in the unevenbedded gravels, as stated by Mr. Kennard, indicate that the deposits were formed under cold conditions similar to those which must have prevailed during the accumulation of the deposits at Barnwell Station. Organisms indicative of cold conditions occur in such parts of the gravels of the Barnwell, intermediate and lower terraces as were deposited during the period of erosion following the period of aggradation. This would show that cold conditions which set in during the accumulation of the unevenbedded gravels of the Travellers' Rest Pit continued until after the deposition of our newest Pleistocene deposits. Apart from what we regard as true glacial accumulations the presence of *Columella columella* in the deposits of both the highest and lowest terraces, and its apparent absence in deposits of an age intermediate between these, may indicate that the climatic conditions during the formation of these latter deposits were somewhat less cold than those of the period of the *Columella*-bearing accumulations. One of us has previously argued that there were indications of the coming on of glacial conditions after the formation of the unevenbedded gravels and overlying rubble drift in this pit. The nature of the clay described in the last section seems to us to give additional evidence in favour of this, though we have to admit that it cannot be regarded as a typical boulder clay. In this connection we would refer to the strikingly similar features displayed in a pit at Eye recently described by us in this Magazine, Vol. LXV, 1928, p. 210

(3) *Green End Road.*—We have here another case, in addition to the one met with in the pit on the Downing site and neighbouring exposure in the Botanic Gardens, that the Barnwell Abbey deposits are not confined to the Barnwell Terrace of the Survey, and it is only a coincidence that the exposures of beds of this age described by the earlier observers happened to be in excavations made in the Barnwell terrace. It would appear that the oldest of these deposits, owing to the large amount of clayey and chalky materials they contain, resist erosion in the same way as the Cretaceous deposits on which they rest.

III. CONDITIONS OF DEPOSITION OF THE PLEISTOCENE DEPOSITS AROUND CAMBRIDGE.

The time appears to be ripe for a general review of the evidence so far accumulated concerning the deposition of the Pleistocene deposits of our area. We will take them in the order of age as assumed by us. The oldest deposits as revealed in the valley sections are those we speak of as the *Corbicula* beds, although they have not always yielded this shell. (They are the Barnwell Abbey beds of Mr. Kennard.) They contain, however, abundant boulders indicative of glacial conditions prior to their formation. We regard them as indicative of warm conditions, although we are aware that this conclusion has been criticized. But the fact that we get both mammalia and mollusca now characteristic of countries warmer than our own and unmixed with those indicative of colder conditions seems to us to be conclusive. We unfortunately know little of the higher beds of this series. We have not so far attempted to work out all the deposits formed during the period of aggradation, so cannot state at what period in our sequence warm conditions had been replaced by colder, though this had certainly occurred before the deposition of the unevenbedded gravels of the Travellers' Rest Pit. There is some doubt whether the beds of Barnwell Abbey age are lacustrine or fluviatile, and the matter is not yet ripe for discussion, though there are some indications that the lower part is lacustrine. The lower evenbedded gravels of the Travellers' Rest Pit were probably deposited in direct sequence with the *Corbicula*-bearing beds, though the lake, if it existed, may then have been filled in and the subsequent deposits would be truly fluviatile. There is much very fine loam associated with these evenbedded gravels at the Travellers' Rest and neighbouring pits. In particular there are two conspicuous thin bands, about a foot apart, seen throughout the Travellers' Rest Pit, save where cut through by channels of the overlying unevenbedded gravels. These may be loess blown on to the surface of the flood plain. Similar loams of much greater thickness have been observed in deposits at Newmarket and Exning in deposits which we regard as of the same age, where their similarity to loess is remarkable. (See note by Dr. Rastall in a paper by one of us.[1])

If we are correct in supposing that the *Corbicula* beds and those succeeding them in age are Acheulean, these loams would correspond generally with the older loess of the Somme. The upper beds with the loams may have been formed under steppe conditions.

The unevenbedded gravels and their contents indicate a climatic change to colder conditions. The irregular bedding itself would hint at more turbulent streams such as occur in flat tracts in front of a glacier, while the patches of more even and finer deposits occurring in them here and there would suggest pools occurring on such tracts.

Mr. Kennard calls attention to the fact that the shells which we have found are mostly terrestrial or at most marsh-loving, nevertheless, as stated before, we are of opinion that all the deposits of the unevenbedded gravels are of aquatic origin.

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[1] *Q.J.G.S.*, vol. xxxii, 1926, p. 116.

We have unfortunately so far obtained no plants from this series, but the resemblance of the mollusca to those of Barnwell Station Pit suggests tundra conditions for which, as will be seen later, there is more abundant evidence at the latter locality.

The next deposits in order of age are the Rubble drifts seen at the Travellers' Rest Pit, also at Little Chesterford and at Kentford. These seem to be truly terrestrial and resemble deposits known by the same name in the south of England, which are admittedly formed under cold conditions. These characters have been described elsewhere.

The unevenbedded gravels appear to be of Micoque age, possibly also lower Mousterian.

The next episode seems to have been the occupation of the district by land ice which produced contortion in the underlying beds and deposited the clay at the Travellers' Rest Pit just spoken of above.

Concerning the upper unevenbedded gravels of the Travellers' Rest Pit we can say nothing, for nothing has been yet found in them, and although the clay-with-race of the Huntingdon Road has been referred to as coming next in the sequence we are still in the dark as to its age and origin.

The next in age we consider to be the newer gravels of the Barnwell Terrace, and succeeding them those of the Intermediate Terrace, These also contain loams of a nature similar to those of the lower beds of the Travellers' Rest Pit, and like them may also indicate steppe conditions and be equivalent to the newer loess of the Somme, but more evidence is required on this point. The deposits themselves seem to be of Aurignacian and passing up into Solutrian age.

Lastly, we have the deposits of Barnwell Station, indicating as already stated, a slight increase of cold: the evidence for these being tundra deposits is strong. The peat seams contain abundant mosses which have not yet been described; plants, shells, and mammalia alike indicate Arctic conditions, and Professor Lesne of Paris permits us to state that the same is true of the insects of which he has made a preliminary examination. Of the mammalia, the reindeer is a tundra animal. These deposits are provisionally referred to Magdalenian times. The sequence of temperate, steppe, tundra, and glacial conditions is in accordance with the views long ago expressed by Nehring (GEOL. MAG., Decade II, Vol. X, 1883, p. 51). Such a change must have occurred before each glaciation, and in inverse order after it, and with more than one glaciation the cycle would recur. This appears to have been the case in Britain, including as above indicated in our own area, though as we have not here a full sequence of deposits all the stages are not represented.

REPORT ON THE NON-MARINE MOLLUSCA.

By A. S. Kennard, A.L.S., and B. B. Woodward, F.L.S.

"New Road site of Agricultural Show off Trumpington and Cherry Hinton Road."

Pupilla muscorum (Linn.)
Succinea pfeifferi Rassm.

Probably a late Pleistocene deposit.

"Travellers' Rest Pit. Lower Bed."

Limnaea truncatula (Müll.)
Pupilla muscorum (Linn.)
Columella columella.
Succinea oblonga Drap.

This faunule indicates cold conditions. It should be noted that truly aquatic species are absent. Three are damp-loving land species, whilst *Limnaea truncatula*, represented by a single dwarfed example, will often flourish in a mere puddle.

"Sewer cutting, Green End Road, 450 yards S. by W. of Milton Road level-crossing."

Bithynia tentaculata (Linn.)
Valvata piscinalis (Müll.)
Limnaea truncatula (Müll.)
Planorbis vortex (Linn.)
Planorbis leucostoma Mill.
Pupilla muscorum (Linn.)
Eulata fruticum (Müll.)
Fruticicula hispida (Linn.)
Succinea pfeifferi Rassm.
Sphaerium corneum (Linn.)
Pisidium amnicum (Müll.)
Pisidium cinereum Ald.
Pisidium nitidum Jen.
Pisidium henslowanum (Shepp.)

This deposit is of the same age as the well-known gravel of Barnwell Abbey.

The Red Rocks between the Carboniferous and Trias, and the Spirorbis Limestones of the Keele Beds, in the Birmingham District.

By Professor W. S. Boulton, D.Sc., F.G.S.

IN a paper published in 1924[1] the writer described a breccia passed through in a boring at Nechells, Birmingham, which is there about 350 feet thick, overlain unconformably by the Keuper Sandstone, and lying unconformably on the Calcareous Conglomerate Group (= the Corley Beds), which is included in the Carboniferous by the Geological Survey.

The Nechells Breccia was compared with other breccias in the Midlands, including those of Hopwas, Clent and Northfield, and arguments were adduced to show that there is an unconformity of varying degree above and below all these breccias and that failing good evidence to the contrary, they should remain in the Permian.

Since then further evidence has been obtained which should help towards a final judgment as to whether Permian rocks exist in the English Midlands. The writer's present intention is not to discuss the general question of retaining the Permian as a separate system, but to record the new facts and some obvious inferences drawn therefrom.

The new evidence is dealt with under two heads: (1) A recent deep boring at Windsor Street Gas Works, Birmingham; (2) exposures in shafts, borings and trenches on or near the site of the new Birmingham Reservoir at Frankley, 5 miles south-west of Birmingham.

I. Windsor Street Gas Works Boring.

A boring for water was made in 1925 at a spot about 280 yards south of the old boring,[2] and about $\frac{3}{4}$ mile W.S.W. of the Nechells boring. It is not necessary to state here the full details of the boring, and the following is a short summary of notes on the cores taken while the boring was in progress.

Notes on the Boring.—It starts at 350 feet O.D. and goes to a total depth of 806 feet. Drift extends down to a depth of 45 feet, below which, and to a depth of 210 feet, is the Keuper Sandstone, deep red in colour and often flaggy, with highly micaceous bands. From 210 to 382 feet are brownish-red and buff, rather coarse and even-grained sandstones, with minute white grains of decomposed felspar, and with a few small round pebbles scattered in the lower part. This appears to be typical Bunter Pebble Beds, although, as is frequently the case in the upper part, few pebbles are present.

Below 382 feet, the rocks are breccias similar in the main to the Nechells breccia, with intercalated marl and sandstone beds.

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[1] "The Breccia-bed underlying Nechells," *Q.J.G.S.*, vol. lxxx, pt. iii.

[2] Op. cit., p. 352, and the Birmingham Memoir, *Mem. Geol. Surv.*, p. 132.

Unfortunately, the boring could not be carried to the base of the breccia, so that its full thickness is not known, the thickness proved here being 424 feet. Probably the Calcareous Conglomerate Group underlies it as at Nechells. Apart from occasional false-bedding, there was no marked change of dip throughout the cores.

The rock fragments range up to 8 inches or more across. Most of them consist of quartzite, but other rock types are fairly common, especially in the lower parts of the breccia. These include pebbles of purplish-red Cambrian limestone with *Hyolites* (like that in the Nechells breccia); coarse, flaggy, purple and grey grits of Torridonian type; grey and black cherts; pink felsite; decomposed andesite and dense purplish volcanic tuff.

Bands of dull red marl and purplish-brown sandstone occur at intervals, the latter generally 1 to 2 feet thick, but in places up to 6 feet in thickness, some calcareous, others non-calcareous. At several horizons a bed of sandstone rests on an irregularly eroded surface of breccia, or a breccia on eroded sandstone, a feature which was conspicuous in the breccia of the Nechells boring.

Some of the beds, especially from 760 feet downwards, are made up of very hematitic and calcareous breccia, with partially rounded fragments which are obviously wind fretted and highly glazed. Individual bands of fine breccia at this level are very similar in type to the Warley breccias. On the whole the fragments in the Windsor Street breccia are not so large as in the Nechells breccia, and the intercalated sandstones are rather more frequent and thicker than in the latter.

With this additional information of the underground extent and thickness of the Nechells breccia, an attempt will now be made to bring out its relation to the breccias of the Warley-Quinton area, which can be seen there to dip at 15° to 20° eastward under the Bunter Pebble Beds, and which are known to underlie the latter in certain borings in the Birmingham District.

The Section (Fig. 1) passes through the Londonderry boring near Langley Green and thence eastward across Birmingham, taking in the Windsor Street Gas Works boring, from which its direction changes to E.N.E. to include the Nechells boring. Fig. 2 is a copy of the coloured section which is printed with the new Survey one-inch map of Birmingham (Sheet 168). The central part of the two sections is along the same east-west line, and it will be noted that in the Survey section an anticlinal structure in the pre-Triassic rocks is indicated, so that the thickness of the Pebble Beds in the western part of Birmingham is considerably less than in the section (Fig. 1).

The evidence for this anticlinal structure appears to depend upon an interpretation of the boring at Hockley Station, Birmingham, where the base of the Pebble Beds is supposed by the Survey to be at a depth of 242 feet, and below that the Calcareous Conglomerate Group to the bottom at 514 feet.[1]

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[1] Birmingham Memoir, p. 137.

As this boring is critical, it is necessary to state the evidence in some detail. The boring was put down in 1916 to a depth of 614 feet (not 514 feet as recorded by the Survey) and was stopped when a breccia of Warley type was struck from 610 to 614 feet.[1] A specimen of this breccia sent to Mr. W. King by Mr. Bird of the G.W.R. Co. in 1915 is now in the writer's possession. It is a dark brownish-red breccia, with small angular and partly rounded wind-worn chips in a sandy-marl matrix, and in all its characters is indistinguishable from the typical breccia of the Warley area Above this breccia the rocks are red sandstones with thin marl bands, but from 435 to 600 feet the sandstone contains many rounded pebbles, and from 508 to 600 feet it is practically all Pebble Beds. Mr. Eastwood, of the Geological Survey, informs me that he saw specimens of the cores of this boring which he took to belong to the Calcareous Conglomerate Group, and that he saw no breccia. The writer has been at some pains to ascertain the nature of this conglomerate and is convinced that it belongs to the Bunter Pebble Beds and not to the Calcareous Conglomerate Group. The rounded pebbles from the last 100 feet of Bunter, in size up to 8 × 5 inches, are typical Bunter pebbles, and during the drilling they readily detached themselves from the soft red sandstone, so that many had to be brought up separately.

The evidence from neighbouring borings is not consistent with the Survey reading of the Hockley boring. Thus the boring at the Birmingham Workhouse, Winson Green,[2] passed through Bunter Pebble Beds to a depth of 560 feet (see Fig. 1). At the Mint boring, 400 yards to the S.E. of the Hockley boring, Bunter Pebble Beds occurred to a depth of 634 feet, below which came 9 feet of dark red marl with chips, probably the Warley breccia.

Another boring in 1922 at J. Lucas, Ltd., King Street, Lozells, 730 yards east of the Hockley boring, passed through typical Bunter with scattered round pebbles in the lower part to a depth of 500 feet. The writer carefully examined these cores, hoping to get some evidence of the Nechells breccia under the Bunter, but the boring did not go deep enough to reach the Bunter base. A feature of some interest was the occurrence of isolated angular chips of quartzite from 2 to 6 inches across in the red sandstone at various depths from 270 to 459 feet.

Betweeen the Lucas boring and that at Windsor Street Gas Works no boring up to the present has penetrated to the base of the Bunter, so that there is a gap in the section (Fig. 1) of a little over a mile where we have no direct knowledge of the pre-Bunter rocks, although, as the section shows, the Nechells breccia probably underlies the Pebble Beds in this ground.

A boring at Guest, Keen & Nettlefolds, Smethwick, shown in the section (Fig. 1) did not reach the base of the Bunter, but borings Nos. 3 and 5 for Mitchells & Butlers Brewery, 1,000 and 1,400 yards, respectively, to the south of the Guest, Keen & Nettlefolds boring, proved the Bunter base at −63 and −171 O.D., respectively, resting on red marls and breccia. From these data it is possible to fix approximately the position of the Bunter base at this point in the section as about + 30 O.D.

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[1] Nechells paper, p. 352.

[2] Birmingham Mem., p. 135.

It will be seen therefore that the Bunter Pebble Beds to the west of Birmingham are much thicker than is shown on the Survey section. This is a matter of some economic importance, because the Bunter is the chief source of underground water in Birmingham. Moreover, if the Productive Coal Measures exist under Birmingham, the coals must be some 700 feet deeper than is indicated by the Survey section.

We can now summarize the result of these new observations, as shown in the section (Fig. 1).

1. The base of the Bunter Pebble Beds along the line of section can be drawn with some approach to accuracy, showing that a basin of Bunter, with its base about 230 feet below O.D. at its greatest depth, exists under west Birmingham, the long axis of the basin running north and south.

2. The division between the Bunter Pebble Beds and the Upper Mottled Sandstone is uncertain and arbitrary, but from evidence obtained from several borings this junction is taken by the writer at a somewhat lower level than that shown in the Survey section.

3. Apart from the known base of the Nechells breccia at the Nechells Gas Works, where it rests unconformably on the Calcareous Conglomerate Group, the geological lines below the base of the Bunter Pebble Beds as shown in the section are conjectural.

4. The evidence now available shows that the Nechells breccia, consisting of a fan of coarse material with a thickness of more than 424 feet at Windsor Street Gas Works, thins somewhat to the E.N.E., and probably thins also to the west (Fig. 1).

5. The underground occurrence of the breccia on the downthrow side of the Birmingham fault is not at present known, but the north-eastward rise of the pre-Breccia Calcareous Conglomerate Group suggests that the unconformable base of the Keuper Sandstone oversteps, not only the two members of the Bunter and the Nechells breccia, but also the Calcareous Conglomerate Group a short distance east of the fault. Further south, however, the Bunter Pebble Beds occur immediately below the Keuper, on the downthrow side of the fault.

6. This north-easterly rise in the pre-Keuper rocks may be related to the exposure of old rocks in Permian and Bunter time which by their denudation yielded material for the breccias.

7. The section (Fig. 1) shows that the Nechells breccia is brought face to face with the Warley breccia group below Hockley and Winson Green.

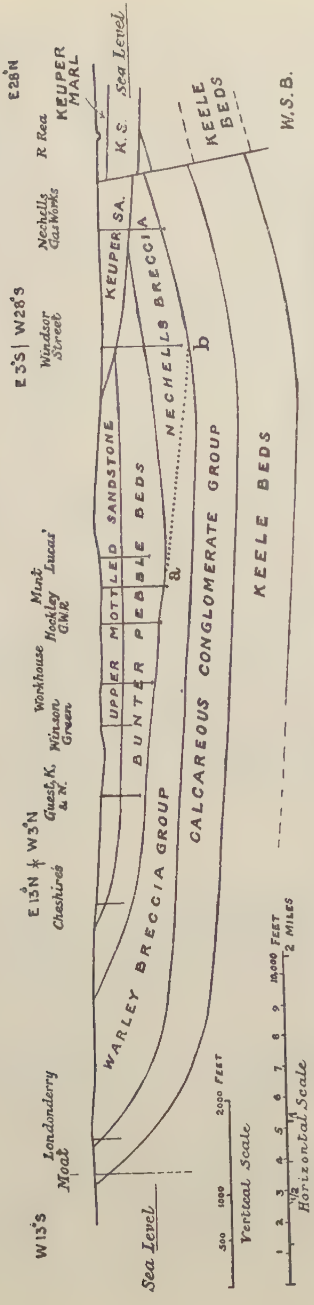

FIG. 1.—Section across Birmingham from Langley Green to Nechells to show the underground structure.

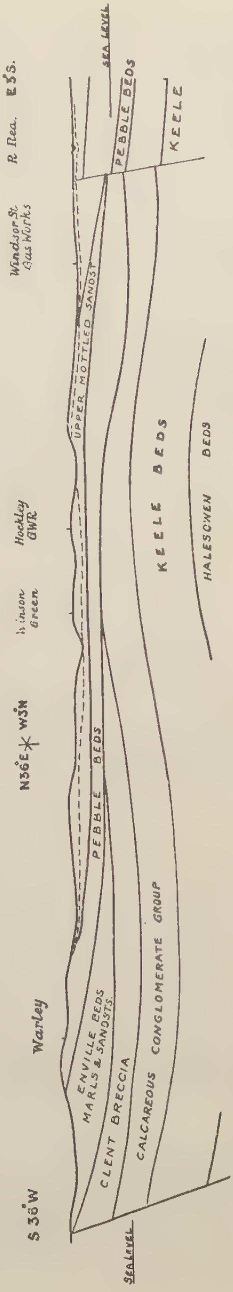

FIG. 2.—Copy of section on Geological Survey 1-inch map of Birmingham.

8. The Nechells breccia can be regarded as an easterly extension of the Warley breccias; and although much of the former may be and probably is somewhat newer than the latter, both appear to form part of the same continuous series of breccias, and to be of the same general age, which in the writer's opinion should be called Permian, so long as the term is recognized as denoting a period distinct from the Triassic period.

9. At Nechells the breccia was shown to be unconformable to the underlying Calcareous Conglomerate Group. While there appears to be no flagrant unconformity at the base of the Warley marls and breccias, there is evidence of a south-westerly overstep of these beds on the Calcareous Conglomerate Group as we pass from N.E. to S.W. In the Hampstead area the exposed Calcareous Conglomerate Group is much thicker than to the south; and between Langley Green and Brand Hall the base of the Warley breccias and marls oversteps the underlying beds.[1]

10. In this connection it is of some interest to note the conclusions come to by Mr. Fleet, from his investigation of mineral residues of the Red Rocks of the Midlands,[2] in which he suggests that the Warley breccias and the Nechells breccia are related in that both have been derived from the same easterly source, although the Nechells breccia may be somewhat newer than those of Warley.

11. If the Nechells breccia is regarded as a basal Triassic bed, and the Warley (Clent) breccias are included in the Carboniferous, which is the present view of the Geological Survey, then the dotted line *a—b* in the section (Fig. 1), which is imagined as separating the two breccia groups, must represent at least the whole of the Permian; and what is probably the biggest stratigraphical break in British geology, involving the great post-Carboniferous earth-movements, would then occur within what appears to be a continuous breccia bed.

II. FRANKLEY AREA.

During the last few years a large new reservoir for Birmingham has been under construction near Frankley, about 5 miles S.W. of the centre of Birmingham, and the opportunity has been taken to record many new exposures in foundations, shafts and trenches, as well as in cores from more than a hundred boreholes which were drilled for cementing the fissured sandstones below the site of the dam and the floor of the reservoir.[3]

The reservoir site is on Keele Beds and $\frac{1}{4}$ mile west of the outcrop of the Northfield breccia which occupies Ley (Merritt's) Hill. As a result of these observations it has been possible to prove that two bands of *Spirorbis* limestone, about 50 feet apart, occur in this ground in the red marl group with thin sandstone bands, lying between the "Hunnington sandstone" below and the Romsley group of sandstones (Enville sandstone of the Survey) above. There is also a third limestone, 8 feet below the Hunnington sandstone, and 93 feet below the middle limestone.

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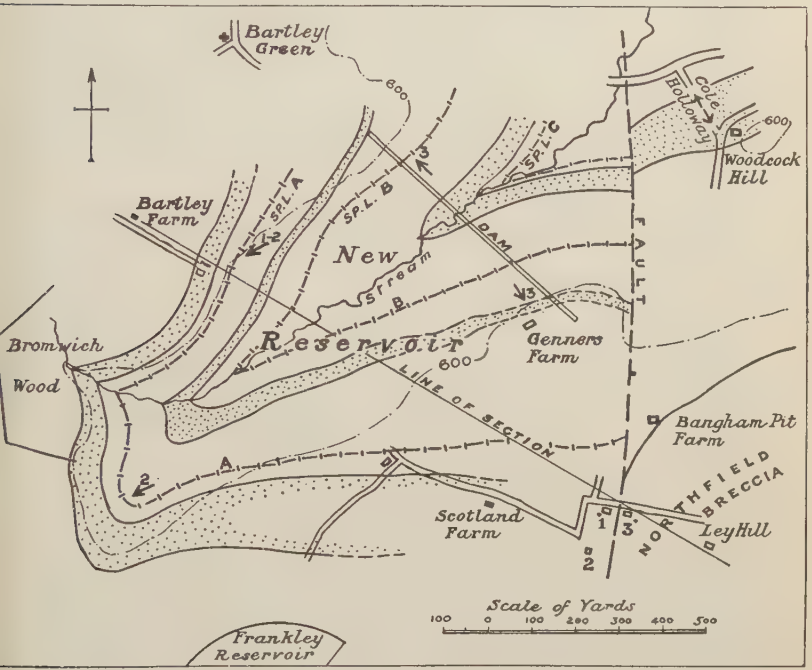
[1] Mem. of Birmingham District, p. 62, and 1-inch map of Birmingham, Sheet 168.

[2] "The Heavy Minerals of the Keele, Enville, 'Permian,' and Lower Triassic Rocks of the Midlands and the Correlation of these Strata," W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxviii, pt. i, 1927.

[3] *Cementation of Strata below Reservoir Embankments*, A. A. Barnes, Inst. Water Engineers, 1927.

Further, three wells sunk for a water supply for bungalows on the western fringe of Ley Hill have yielded valuable information, not only with respect to the *Spirorbis* limestones but also as to the exact position and probable throw of the fault which is drawn on the new Survey map, separating the Breccia from the Calcareous Conglomerate Group, which is assumed by the Survey to outcrop here.



IG. 3.—Geological sketch-map of the site of the new Frankley reservoir, near Birmingham.

The sketch-map (Fig. 3) shows the outcrops of the three bands of *Spirorbis* limestone. The middle band *B*, a dark blue-grey limestone with olive-green veins and streaks of marl and 8 inches thick, is drawn on the recently published 1-inch geological map of Birmingham (Sheet 168). Its outcrop is determined by an exposure in the stream and from a number of borings which penetrated it. The upper band, *A*, was seen to outcrop for some distance on both sides of the reservoir site near the top-water level (O.D. 605), and a good exposure of it was laid bare in an excavation for a channel at the S.W. end near the old stream course, and 270 yards N.E. of Westminster Farm. Here the limestone is 1 foot thick, dips to the S.W. at 2°, and is light blue-grey in colour with red and olive-green strings and patches. It is very like limestone *B* in appearance, except that it is rather lighter in colour.

During the recent survey of the area, Mr. T. Eastwood noted two exposures of *Spirorbis* limestone in Egghill Dingle, which is about 1¼ miles to the S.S.W.,[1] and despite an intervening fault which might repeat the outcrop of the same limestone, he regarded them " as separate bands probably 50 feet, but not more than 100 feet apart ". His observation is now confirmed, for it is probable that they are the same limestone bands as bands *A* and *B* exposed on the Frankley reservoir site.

The lowest limestone, *C*, was pierced in a boring adjacent to Genners Farm, and on the S.E. side of it, at a depth of 134 feet or 477 O.D. The same limestone was traced by Mr. W. G. Lees, assistant engineer to the waterworks, for some distance in the excavation for the main trench near the bottom of the valley and at 520 O.D. Both these levels are about 8 feet below the base of the Hunnington sandstone. The limestone, especially from the borehole near Genners Farm, is very dark blue-grey in colour. Although its position is known so exactly, its outcrop could not be detected because of a cover of drift.

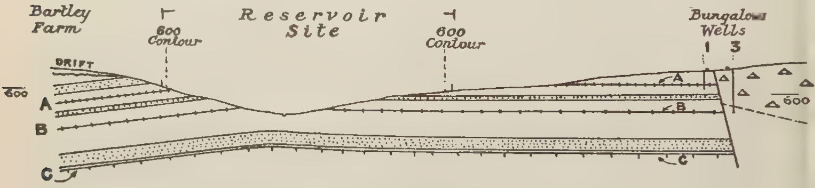


FIG. 4.—Section across reservoir site.

A well adjacent to a bungalow, and about 40 yards S.E. of the junction of Merritt's Hill Road and Woodcock Lane (No. 1 on sketch-map, Fig. 3) passed through a *Spirorbis* limestone band about 1 foot thick and very like Limestone A, with which it is doubtless continuous.[2] The limestone is about 26 feet from the surface, or 620 O.D., and the rest of the rock in the well is bright red marl. Another well (No. 2 on sketch-map), 125 yards S.S.W. of No. 1 well, struck the same limestone at 600 O.D., giving a dip to the south of about 3°, and consequently its outcrop may be inferred to lie about 150 yards north of No. 1 well, as shown on the map, although it is not visible on the ground.

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[1] Birmingham Mem. Geol. Surv., p. 56.

[2] Nechells paper, p. 356.

A tunnel which started at the S.E. end of the reservoir dam at O.D. 570, was driven S.S.W. for 2,500 feet with a fall of ·08 inches in 100 feet. The south end of the tunnel emerges in an open cutting, now a pipe-track. At the north end, limestone *B* was struck, but from this point southward and throughout its length, the tunnel lies in the marl ground which intervenes between limestones *A* and *B*. It follows therefore that limestone *A* must outcrop again in the sloping ground near the southern margin of sketch-map (Fig. 3). Further, this same limestone is probably the one recorded by the Survey and drawn on the new 1-inch and 6-inch maps on the site of the existing Filter Beds.

A vertical shaft to this tunnel, 70 feet deep, was sunk at a spot 100 yards N.E. of Scotland Farm at an early stage of the work which should have passed through limestone *A* at about 30 feet from the surface. It is possible that it was met with, and that the excavated fragments of limestone got buried under the marl dump of the main embankment without being noticed, especially as at that stage of the work the records of the limestones were not so scrupulously kept. But Mr. Lees, one of the engineers, informed me that at another shaft near the N.W. end of the dam, limestone *B* was not found, in spite of a diligent watch for it. In this latter case the horizon of the limestone was certainly passed through, for the proof of its exact position was ample because of the presence of this limestone in several adjacent borings and shafts.

The great value of these bands of *Spirorbis* limestone as datum levels in the Upper Coal Measures is well known, and the occasional absence in a boring or shaft of some particular band where its presence is confidently predicted has often been noted.

It would appear that these thin limestone-bands are peculiarly liable to small " wants " or local thinning, due to contemporaneous solution or erosion. Evidence for this is found in the frequent occurrence of a pellety type of *Spirorbis* limestone, in which small limestone pellets are embedded in a limestone matrix of similar rock.

The proof now available that there are *three* separate *Spirorbis* limestones in the Keele Beds along the southern margin of the South Staffordshire Coalfield permits a more reasonable correlation than heretofore of the *Spirorbis* limestones met with in colliery shafts and borings in the Hamstead-Sandwell Park area, including the outcrops in the railway cutting between Sandwell and Handsworth, west of Birmingham, as well as in the Baggeridge shaft on the western side of the coalfield.

Taking the base of the Keele Beds as adopted by the Survey (*Southern Part of South Staffordshire Coalfield*, p. 122), the following correlation is suggested as best fitting the facts at present known :

Spirorbis Limestones above Base of Keele Group.

Southern Outcrop. Feet.	*Baggeridge.* Feet.	*Sandwell.* Feet.	*Warwickshire Coalfield.* Feet.
360	445	730[1]	700–800 Maxstoke.
310	336	610[1]	400–500 Whitacre.
217	—	209	100–150 Baxterley.

The above correlation supposes that the lowest limestone is absent or was missed at Baggeridge. Although necessarily more speculative, the Warwickshire limestones are included with the Survey figures. It will be noted that the marls between the lowest and middle limestones are about 400 feet thick in the Sandwell area as compared with about 100 feet at the southern outcrop, the total thickness of the Keele Beds in the latter area being at least 300 feet less than in the former.

Combining all the observations in the area of the reservoir site, it is clear that the Keele Beds are folded into a gentle anticline with an amplitude of about 50 feet and a slight pitch to the S.W.

A third well (No. 3 on Fig. 3), 65 yards east of No. 1, was subsequently dug to a depth of 100 feet in the hope of getting a water supply for another bungalow. This well started in the Northfield breccia, and for the first 35 feet passed through marly breccia with hematite-stained angular chips, up to 1–2 inches across, including rhyolite and basic igneous material. Below this and down to 85 feet are marls and breccia with bands of hard, coarse calcareous sandstone containing pebbles, some rounded, others sub-angular. Towards the base, the pebbles, embedded in a dark red sandy marl, are up to 9 inches across, and include brown chert and decomposed rhyolite with much iron staining, some of the pebbles being highly glazed and wind-worn. For the last 15 feet the material brought up seemed to be all red marl.

It may be noted that similar calcareous sandstone bands and many glazed and rounded pebbles occur higher up in the body of the Northfield breccia in the road-cutting of Merritt's Hill. In this and other characters there are marked differences between this breccia and the typical Clent breccia. Indeed, some thin bands in the Northfield breccia suggest comparison with the Calcareous Conglomerate of other localities, and it is significant that Mr. Fleet found typical Calcareous Conglomerate residues in a sandstone from No. 3 well at Ley Hill.[2]

The evidence from No. 3 well appears to show that the base of the Northfield breccia may be here at about 85 feet from the surface, and consequently the junction of the breccia with the Keele Beds is a fault whose outcrop can now be fixed within a few feet. It follows therefore, that there is no outcrop of the Calcareous Conglomerate Group between the Northfield breccia and the Keele Beds.

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[1] These are the two limestones seen by Mr. W. King to outcrop respectively about 100 yards west and east of Halford Bridge in the G.W.R. cutting. "The Sandwell–Handsworth Railway Section," *Proc. Birm. Nat. Hist. and Phil. Soc.*, vol. xv, 1923, pp. 41–6.

[2] Ibid., p. 13.

About 160 yards north of this, the base of the breccia leaves the fault, and swings N.N.E., but for some distance the beds which immediately underlie it are not visible because of a cover of Drift. About 130 yards south of Shendley Court Farm, however, red marl and crumbly brown sandstone are visible in a bank east of the road, and close by is the base of the breccia. These red marls with brown sandstone are probably not far above the upper *Spirorbis* limestone *A*. It appears, therefore, that the fault between the Keele Beds and the breccia is one of small throw, and there is no evidence for the presence hereabouts of the Calcareous Conglomerate Group. The northern continuation of this Ley Hill fault brings down the sandstones of Woodcock Hill against the marls which immediately underlie the Hunnington sandstone. If the fault is of small throw, of the order of 80 to 100 feet, it seems probable that the sandstone exposed in Cole Holloway on Woodcock Hill is a repetition of the Hunnington sandstone, and that between Woodcock Hill and the Northfield breccia to the south we have the Keele red marls with thin sandstones and the three bands of *Spirorbis* limestone, but obscured in outcrop by Drift cover.

The evidence cited above points to the superposition of the Northfield breccia of Ley (Merritt's) Hill on the Keele Beds, at an horizon not far below the base of the Romsley sandstones, or the Enville sandstones of the Survey, and presumably an unconformity separates the two groups.

My thanks are due to Mr. W. H. Laurie, of the Geological Department of the University of Birmingham, for valuable help in taking field records and in drawing the figures which illustrate the paper.

The Occurrence of *Glossopteris* in the Beacon Sandstone of Ferrar Glacier, South Victoria Land.

By W. N. Edwards.

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INTRODUCTION.

THE presence of members of the *Glossopteris* flora in Antarctica was first attested by the material collected from Mount Buckley by Dr. Wilson and Lieut. Bowers on Capt. Scott's last expedition to the South Pole. and the now famous specimens were described by Professor A. C. Seward (1914). Traces of fossil plants in Antarctica, were, however, first discovered by Mr. H. T. Ferrar, a member of the National Antarctic Expedition, 1901–4, and were briefly described by Arber (1907), who reported, on some specimens from the Ferrar Glacier, that " several of these show fair-sized carbonaceous impressions or markings, which in all probability are of vegetable origin". The evidence presented by this unpromising material did not "permit of any opinion as to the botanical nature or affinities of the fossils themselves, nor of the geological age of the beds in which they occur" (Arber, 1907, p. 48). Professor Seward examined the specimens and agreed with this conclusion (1914, p. 2).

GLOSSOPTERIS.

The material collected by Mr. Ferrar is in the Geological Department of the British Museum (Natural History), and, in the course of re-arranging part of the Museum collections, I recently had occasion to examine it. One of the specimens was a rather large block of hard shale with bands of carbonaceous matter. The impressions on the surface were unrecognizable, but it seemed obvious that such a block might prove to be of more value if it were broken up, since it would be no great loss if it happened to be destroyed in the process. The shale was therefore carefully split open by Mr. F. M. Wonnacott, and we were at once rewarded by finding several undoubted fragments of *Glossopteris* fronds. The preservation is by no means good; the fronds are black impressions on a dark, often black shale; and the veins, when preserved at all, are faint silvery lines. However, as Professor Seward has said, *Glossopteris* is "one of the few genera that can be identified with confidence from fragmentary specimens" (1914, p. 6).

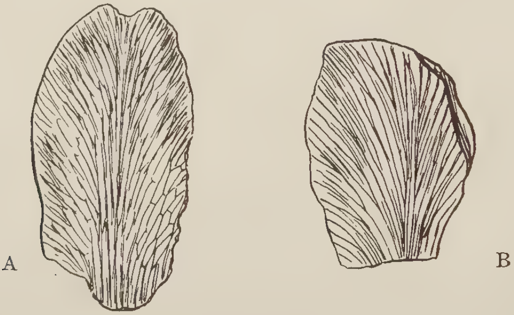

FIG. 1.—*Glossopteris indica* Sch., from Ferrar Glacier. A. Fragment with anastomosing venation clearly shown at one point on the right-hand side. × 2. V. 20445. B. Smaller fragment; anastomoses not clearly seen. × 2. V. 20447.

The specific identification is by no means simple, as will be apparent from the drawings of the best specimens. One of these is a small, almost spathulate leaf 2 cm. in length (incomplete), with a rather indistinct midrib, but with the anastomosing veins shown very clearly at one point (Fig. 1*a*); another is oval in form, 4 cm. in length (incomplete) and probably about 3·5 cm. in width

(Fig. 2). The venation varies considerably, especially in the angle made by the secondary veins with the midrib, but this variation is no more than might be expected in different leaves of a single species, and no more than is to be seen in the specimens from Mount Buckley figured by Seward (1914, pl. iii) as *Glossopteris indica* Schimper and *G. indica* var. *wilsoni* Seward. The latter were distinguished by the rarity of anastomoses between the secondary veins. Specimen V. 20446 (Fig. 2) from Ferrar Glacier resembles Seward's var. *wilsoni*, but even the secondary veins can only just be distinguished, and the apparent rarity of anastomoses may only be due to the poor preservation. This explanation may also apply to the specimens of *G. indica* var. *wilsoni* from Mount Buckley, which are by no means well preserved. Whether this is so or not, I think that the custom of applying varietal names to isolated fossil leaf impressions is to be deprecated. As Professor Seward himself has said (1910, p. 507), speaking of *Glossopteris*: "The arbitrary separation of sterile leaves, which differ by small degrees from one another in form and in the details of venation, by the application of specific names is a thankless task necessitated by custom and convenience; it is, however, idle to ignore the artificial basis of such separation." The use of trinominal nomenclature does not appear to add to the convenience of this artificial classification, and I think that in view of the imperfect preservation the Antarctic specimens of *Glossopteris*, both from Mount Buckley and Ferrar Glacier, should all be referred to a single form species. This may for the present be named *Glossopteris indica* Schimper. It is now usual to separate *G. indica* from *G. browniana*, though Professor Seward at one time united them. It is true that extreme forms may be distinguishable; but since neither Zeiller nor subsequent authors have clearly indicated any tangible line of demarcation between the two species, one should not attach undue importance to identifications from imperfect or poorly preserved material,

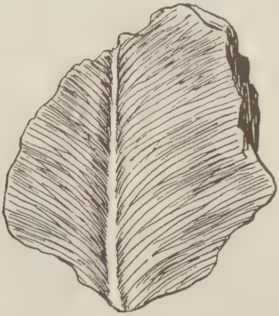

Fig. 2.—*Glossopteris indica* Sch. Ferrar Glacier. Incomplete leaf with nearly parallel veins and with apparently few anastomoses. Natural size. V. 20446.

for instance, in considerations of geographical distribution. The point to be emphasized here is that a *Glossopteris* of the *G. browniana* group occurs in Antarctica at Ferrar Glacier, some 500 miles north of the locality at Mount Buckley.

Two very imperfect fragments resemble the poorly preserved impressions from Mount Buckley, figured by Professor Seward (1914, pl. iii, fig. 17) as possible scale-leaves of *Glossopteris*. The Ferrar Glacier specimens are larger, but they also are unidentifiable. They may only be ordinary fronds poorly preserved.

Dadoxylon.

The flattened oval form of some of the carbonaceous specimens collected by Mr. Ferrar indicates the presence of plant stems, some several inches in diameter. Flakes of carbonaceous matter from some of these stems, examined by reflected light under the microscope, showed traces of the structure of gymnospermous wood. With the aid of collodion films it was possible to ascertain that the bordered pits on the radial walls of the tracheides were in one or two rows, and usually in contact; that the tangential walls were also pitted; and that the medullary rays were only a few cells in height. Wood of this type may be referred to the comprehensive form-genus *Dadoxylon*, but the possibility of identity with the wood from Priestley Glacier described by Professor Seward as *Antarcticoxylon priestleyi* is not excluded, since the radial pitting is similar. Seward's species has since been transferred by Walton (1923) to *Rhexoxylon* Bancroft, a genus founded on characters that cannot be fully determined from fragments of secondary wood only. Neither in *R. priestleyi* nor in the wood here described is the field pitting preserved, and so far the occurrence of tangential pitting has not been noted in any species of *Rhexoxylon*. The question of the

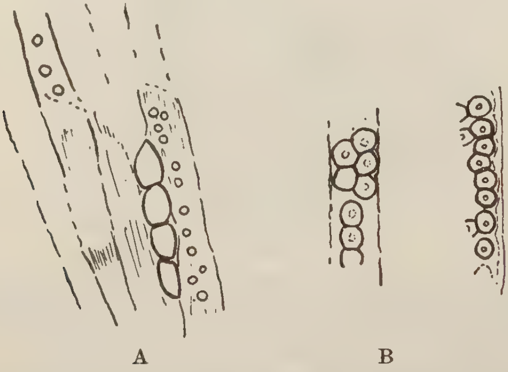

Fig. 3.—*Dadoxylon* sp. Ferrar Glacier. Fragments of secondary wood detached on collodion films. Highly magnified. A. Tangential (V. 20450*a*). The medullary ray is only an impression on the film. B. Radial (V. 20451*a*).

possible relationship between *Rhexoxylon* and some of the Gondwanaland woods referred to *Dadoxylon* has already been discussed by Walton (1923).

CONCLUSIONS.

The following plants (not including some indeterminable remains) have previously been recorded from the Beacon Sandstone of Antarctica (Seward, 1914):—

Glossopteris indica Schimper.
Glossopteris indica var. *wilsoni* Seward.
Vertebraria sp.
Rhexoxylon priestleyi (Seward).
Pityosporites antarcticus Seward.

I agree with Walton (1925, p. 11) in regarding the supposed spore, *Pityosporites antarcticus*, as merely a shrivelled pith cell. *Vertebraria* is a part of the plant which bore *Glossopteris*, so that the list may be reduced to the latter and a gymnospermous wood. The material collected by Mr. Ferrar has also yielded only *Glossopteris* and a gymnospermous wood. With the small amount of available material it is impossible to say whether this has any special significance, and the problem of whether or not *Glossopteris* was borne on a tree having wood of the *Dadoxylon* type will probably be settled in some other part of Gondwanaland.

The significance of the occurrence of *Glossopteris* in Antarctica has been fully dealt with by Professor Seward (1914), who also gives an account of the geology of the Beacon Sandstone, with references to the earlier literature. According to Ferrar, the Beacon Sandstone of South Victoria Land is about 2,000 feet thick, and the fossiliferous band with *Glossopteris* is near the top. The specimens here described are from a band 50 feet above the ice, below Hill B 1, in the south-west arm of Ferrar Glacier, about 7,000 feet above sea-level (Ferrar, 1907, pp. 41, 99). It is satisfactory to record that the material collected by Mr. Ferrar is of greater interest and importance than was formerly supposed.

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REVIEWS.

OVER DE SAMENSTELLING EN HET ONSTAAN VAN KRIJT EN MERGELGESTEENTEN VAN DE MOLUKKEN. (On the Composition and the Origin of Chalks and Marls of the Moluccas.) by TAN SIN HOK. Jaarboek v. h. Mijnwezen in Nederlandsch Oost-Indie, 1926, Verhandeling III. 165 pages, 16 plates, and 2 figs. in the text. The Hague, 1927.

CHALKS and marls of Upper Tertiary, probably Pliocene, age, collected by Dr. R. D. M. Verbeek (1898–9), by the first Netherlands Timor Expedition (1910–12) and by Professor Dr. H. A. Brouwer (1915) were examined petrographically and palaeontologically.

Palaeontological Results.—Stellate and rosette-shaped bodies of aragonite are supposed to belong to planktonic organisms; they are brought into a new group, *Discoasteridae incertae sedis*, in which the following genera are distinguished: *Heliodiscoaster*, *Eudiscoaster*, and *Hemidiscoaster*. The Discoaster fauna of the Moluccas shows rather great differences from that of Barbados.

Among the *Coccolithophoridae* the coccoliths predominate, whereas the rhabdoliths are subordinate. The greater part of the *Foraminifera* found are pelagic, the benthonic foraminifera are very subordinate.

The *Radiolarian* fauna of Rotti was amply treated: four new genera were found, viz. *Cenolarcopyle*, *Hemicryptocapsa*, *Stylocryptocapsa*, and *Holocryptocapsa*; a description of 141 species (including varieties), of which 138 are new, is given. The number of the radiolarian families found is small, some of the families, as *Cyrtocalpida*, *Theocyrtida*, and *Lithocampida* on the contrary are very rich in species. Haeckel's systematic principles were followed rigorously, notwithstanding the author's opinion that the smaller categories as genus, species were founded on too detailed differences. In following the system of Haeckel the student of a radiolarian fauna is certain to be forced to create many species.

Mostly the Cyrtoidea found belong to the *Corocyrtidae* (Popofsky), Cyrtoidea which are phylogenetically the highest developed. Some Eucyrtida show structures which support the opinion of a periodical length-growth.

Both from deductive and inductive considerations the author cannot assign a stratigraphical value to the radiolaria.

Sediment-petrographical Results.—The following groups were distinguished: Globigerina-chalks (from Rendjuwa, Savu, Rotti, Timor, and Ambon), Discoaster-coccolith-chalks (from Rotti and Timor), Radiolaria-coccolith-chalks (from Rotti), Globigerina-marls (from Jamdena and Halmaheira).

In the Glob.-chalks the pelagic foraminifera, chiefly the

Globigerinae predominate; the Discoaster-cocc.-chalks are characterized by the absence of greater foraminifera; in the Rad.-cocc.-chalks radiolaria occur exclusively, whereas the foraminifera are totally absent.

The components of the groundmass of the Glob.-chalks are calcite and aragonite-grains and prisms, coccoliths, calcospherulites, Discoasters, and volcanic minerals, mentioned in the order of their importance. The Disc.-cocc.-chalks are entirely composed of these same groundmass-components. The groundmass of the Rad.-cocc.-chalks consists of calcite and aragonite-grains and prisms, coccoliths and volcanic ash-components, whereas Discoasters and calcospherulites are entirely absent.

For the reconstruction of the environments of sedimentation great stress is laid on the properties of the sediments.

For the diagnosis of the environments in which these chalks were deposited the calcospherulites and the radiolaria were of great importance. The calcospherulites were considered as chemical precipitates and brought in direct connection with the putrefaction of the planktonic organisms. Their presence as essential component in the Glob.-chalks was considered as an indication of an origin in a warm, shallow sea. So, to the Glob.-chalks, notwithstanding their character of an abyssal ooze, an origin in a shallow sea was attributed. A palaeogeographical reconstruction of this sea could not yet be given. The Disc.-cocc.-Chalks were considered as the finer washing-products of these Glob.-chalks.

In connection with Haeckel's opinion that the morphology of the radiolarian skeleton is influenced by the depths in which the organisms live, the radiolaria of Rotti were compared with each other in the thickness of the wall, and in the length and in the breadth of their skeletons. The result was that the Rad.-cocc.-chalks could be arranged in an undeniable sequence, from which some bathymetrical conclusions were drawn, which at the moment cannot be but relative.

The attention is called to the morphology of the radiolaria in connection to the depth in which they live and to the value of these organisms as "bathymeters" for the radiolarian cherts.

The study closes with an explanation of the technique of the making of the preparations and with an appendix on the tuffs of Timor.

Astronomy and Cosmogony. By J. H. Jeans. pp. x + 420, with xvi plates and 63 figures. Cambridge University Press, 1928. Price 31*s*. 6*d*.

THE greater part of this beautifully produced and illustrated book is beyond the scope of this Magazine, since it includes a mathematical treatment of the latest developments of astronomy and cosmogony, although it should be said that there are often several consecutive pages without an equation. The author batters our brains with overwhelming numerical immensities: space measured by hundreds of millions of light-years, temperatures of millions of millions of degrees; densities expressed in tens of thousands; pictures of the universe in which the solar system appears as the tiniest sand-grain in the desert of space, a minute bubble in the stream of time. Nevertheless here and there the geologist may pick out a crumb of comfort, especially with regard to estimates of the age of the solar system and of the earth itself. Here the figures do become more or less such as the mind can conceive. The earth and the other planets, according to Dr. Jeans, must have been born from the outer envelopes of the sun at some time between 1,500 and 5,000 million years ago, the smaller figure being perhaps the more closely in agreement with terrestrial data. The atoms in the outer layer of the sun from which the earth was formed do not constitute an average sample of the sun, any more than our atmosphere gives an average sample of the earth. This accounts for the much lower capacity of terrestrial elements to generate energy by disintegration, a point of much importance in earth-history, since it allowed the surface to be cool enough to support life throughout the geological ages.

A word may perhaps be added as to the author's forecast of the trend of cosmic processes. He fully accepts the view that the source of stellar energy is the annihilation of matter by neutralization of electrons and protons, thus setting free radiation of equivalent mass. The end of the universe is visualized as a complete conversion of matter into wandering radiation. But this is far off: even the sun should last, much as now, for millions of millions of years, so there is time yet for much geological evolution. As usual, though the end is predicted, there is no suggestion as to a beginning: the author speaks of "evolution from chaos" which sounds, allowing for a different mode of expression, much like the first verse of the first chapter of the Book of Genesis.

SECTIONS OF STRATA OF THE COAL MEASURES OF LANCASHIRE. By G. HICKLING. pp. xxxiv + 270, with a folding map and table. Compiled for the Lancashire and Cheshire Coal Association, and printed by Andrew Reid and Co., Newcastle-upon-Tyne, 1927.

SOME time ago we noticed in these columns the fine contoured map of the Trencherbone Seam of South Lancashire, to which the present volume is complementary. It shows in very numerous sections the vertical interval between the aforesaid seam and any other at the various points, and so enables the depth to any chosen seam at any point to be ascertained by calculation from the data shown on the map. The book cannot fail to be of very great value to coal-owners in the district.

REPORTS AND PROCEEDINGS.

Glasgow Geological Society.

9th February, 1928.

"The Geology of Loch Lomond." By Professor J. W. Gregory, D.Sc., F.R.S.

Loch Lomond is the largest lake in Great Britain and the third deepest, with one stretch of 600 feet below sea-level. It is often claimed as the most picturesque of British lakes owing to the contrast between its two divisions, of which the northern is a fiord and the southern a fiard. The loch is crossed by the Highland Boundary Fault, which there subdivides into two branches. To the north of this fault is a series of slates and grits which have been generally regarded as passing by increasing metamorphism into schistose-quartzites, chlorite-mica-schists, and albite-gneiss; and as it is further held that this gneiss passes upward through a schistose series to the Moine gneiss, the slate-grit series has been claimed as the oldest rocks in Scotland. There is a gradual increase in metamorphism through the Loch Lomond series northward from the schistose-quartzites north of Luss to the albite gneiss in the centre of the anticline which crosses the loch. The schists are separated from the slates and grits by a relatively abrupt junction. These grits and conglomerates are composed of fragments of the Dalradian schists to the north, and the lithological evidence proves the slates to be post-Dalradian, as clearly as do the graptolites and radiolaria for the Highland Border Series. The slate-grit series is described as the Lennoxian and it passes from the Gareloch through Luss and Aberfoyle to Dunkeld; it always includes grits and conglomerates formed of debris of the schists.

The Loch Lomond dykes, including one determined by Dr. Tyrrell as malchite, are Devonian and Permian; none is of Kainozoic age. They do not therefore prove that the Loch Lomond basin is later than the Kainozoic volcanic period; but that conclusion is justified by analogy with the fiord valleys further west.

The basin, as advocated by Kinahan, is of tectonic origin due to subsidence along Pliocene fractures connected with a sheaf of north to south faults, some of which are conspicuous from the loch. The basin is asymmetric, the ground to the west having been tilted by subsidence, leaving the eastern wall as a fault scarp, now much denuded. A glacier flowed down Loch Lomond before the Upper Paleolithic, and deposited the terminal moraine which is well-preserved in Glen Fruin, and of which fragments occur in the Endrick Valley, where most of the moraine was destroyed during the submergence of the country. The sea occupied the southern part of Loch Lomond after the deposition of the Croftamie clay with reindeer.

The shelly boulder clay and shelly gravels, in agreement with the view of R. J. Jack, are regarded as of marine origin. During the submergence of the 100 feet beach the northern end of the loch was still occupied by ice, which gradually receded, depositing the moraines in the northern part and in Glen Falloch.

GEOLOGISTS' ASSOCIATION.

30*th March*, 1928.

A. G. Davis: "The Geology of the Clapham-Morden Railway Extension."

The reconstruction and extension of this railway was carried out during 1923–5. The portion of the railway studied lies between Stockwell and Morden, and in this paper descriptions of sections along 5 miles of tunnels are given.

The tunnels were cut mainly in the lower beds of the London Clay. At Tooting folding brings the Woolwich beds nearly to the surface and the whole series were passed through between Trinity Road and Merton—¾ mile. Reference was made to the Wimbledon-Deptford Fault. The paper includes faunal notes on (*a*) Woolwich Beds, (*b*) London Clay, and (*c*) Bryozoa of the London Clay.

Miss Helen M. Muir-Wood, M.Sc., F.G.S.: "A New Brachiopod, *Discinisca ferroviae*, from the Woolwich Beds."

Several specimens of a small conical shell, attached to shells of *Ostrea bellovacine* in a limpet-like manner, occur in the lower part of the Woolwich Beds. These shells are chitinous and are ornamented by radial striae. The only specimen previously obtained was referred to the gastropod genus *Patella* by Prestwich. After careful comparison with recent forms, however, they have been referred to the brachiopod genus *Discinisca*.

Recent species of *Discinisca* are shallow-water marine forms with chitinous shells, which are closely attached to foreign objects or other shells by a short pedicle.

E. M. Venables: "The London Clay of Bognor."

Compared with other London Clay areas, Bognor is practically terra incognita. Interest in the district has lapsed for a considerable time, and no palaeontological divisions have been recorded. The Bognor Rock is known to be fossiliferous, but the clay beds have been wrongly regarded as of almost Barton age.

The section is, however, rather interesting, and the paper contains descriptions of some divisions characterized by certain species of fossils (e.g. "Astarte Bed," "Starfish Bed," "Pholadomya Bed," etc.). The Barn Rock differs from the Bognor Rock in being a glauconitic sandstone, while the latter is an arenaceous limestone and each has its characteristic fauna. The list of species includes some rare and interesting forms, and several new species also occur.

OBITUARY.

J. A. Thomson.

We regret to announce the death of James Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst., Director of the Dominion Museum, Wellington, New Zealand. Dr. Thomson was the first Rhodes Scholar of New Zealand University. After completing his training at Oxford under the direction of Professor W. J. Sollas, he did petrological work in Western Australia, and later studied the inclusions in volcanic rocks from the Ross Archipelago in the Antarctic. On his return to the Dominion he was attracted to Palaeontology, and in 1911 was appointed Palaeontologist to the Geological Survey under P. G. Morgan. In 1913 he inaugurated a series of palaeontological bulletins with his " Materials for the Palaeontology of New Zealand ". His studies of the stratigraphy and palaeontology of the Waipara and Weka Pass districts placed the New Zealand Upper Cretaceous Tertiary sequence on a firm basis.

After his appointment to the Dominion Museum in 1914 he commenced his studies of Tertiary and Recent brachiopoda, and soon established an international reputation. His final work, *Brachiopod Morphology and Genera* (*Recent and Tertiary*), published happily before his death, represents the result of more than ten years study of that group, and is a magnificent monument to his memory.

Dr. Thomson, in spite of his failing health, took a major part in the scientific affairs in the Dominion. He was editor of the *New Zealand Journal of Science and Technology*, secretary to the Board of Science and Art, an original fellow of the New Zealand Institute, and just before his death President of that body. In 1923 he was awarded the Hutton Memorial Medal.

The scope of his activities was wide, and he was able to bring to bear on scientific matters a well-trained, keen intellect, and a high capacity for original research.

His death is a great loss to science, but his work will bear fruit and his example stimulate. R. S. Allan.

Percy Gates Morgan, M.A.

Born 2nd September, 1867. Died 26th November, 1927.

We regret to announce the death, on 26th November, 1927, after a short illness, of Percy Gates Morgan, Director of the New Zealand Geological Survey. The late Mr. Morgan received his training at Otago University School of Mines, Dunedin, and graduated Master of Arts of New Zealand University in 1891. After a varied experience of practical mining he joined the staff of the

New Zealand Geological Survey, and was appointed Director after the resignation of J. M. Bell in 1911.

He was by training and inclination a mining geologist, and under his direction, and through his activities in the field, there appeared a succession of bulletins dealing primarily with the coal and gold resources of the Dominion. At the same time, by his sympathetic co-operation, J. A. Thomson was able to inaugurate a series of palaeontological bulletins which have placed New Zealand palaeontology on a firm basis.

P. G. Morgan was by nature cautious, thorough, and painstaking. He had a wide knowledge of geological literature and thought, and a high ideal of the functions of a state geological survey.

R. S. ALLAN.

Wilhelm von Branca.

BORN 9TH SEPTEMBER, 1844. DIED 12TH MARCH, 1928.

With Wilhelm von Branca one of the most prominent German geologists has passed away. The active part of his life is now somewhat remote, for he retired more than ten years ago (1917). Thus for the younger generation his geological work has more of an historical nature, but it is our duty to pay tribute to the fame of a great master whose name will always be associated with vulcanology and matters connected therewith.

Wilhelm von Branca was born in 1844 at Potsdam, near Berlin. He studied at Greifswald, Halle, Heidelberg, Rome, Berlin, Strassburg and Munich. He graduated at Heidelberg (Dr. phil.) and Tuebingen (Dr. rer. nat.) in 1876. In the same year he became a demonstrator in Mineralogy at Heidelberg, 1881. He began his career as lecturer in Berlin, in the same year in Aachen. One year later he joined the Geological Survey at Berlin. In 1887 he was made a Professor of Mineralogy at Koenigsberg and fulfilled the same function from 1890 to 1895 at Tuebingen and 1895 to 1899 at Hohenheim. He was then called to Berlin as the successor to Leopold von Buch. He taught geology here up to 1917, when he retired and was succeeded by J. F. Pompeckj. His work, the fruit of strenuous untiring effort, won for him recognitions both at home and abroad. Thus he was made a " Geheimer Bergrath " in 1898, an honorary Doctor of several German universities, and was elected a Fellow of the Royal Academies of Berlin and St. Petersburg.

Practically in all branches of geological work Branca has left great contributions. His Doctorate thesis dealt with the volcanoes of the Herniker district (Italy) and vulcanism remained his favourite subject. Among the most important publications which were partly of a mere theoretical and partly of stratigraphical nature two works are especially outstanding, both of which have shown new ways to geology. These were *The Embryonal Volcanoes of Suabia* (Schwabens 125 Vulkanembryonen), 1892–8, and his theories on the origin of the Ries of Noerdlingen and the neighbouring cryptovolcanic basin of Steinheim (1901–1913). The latter were frequently atacked (Koken, Penck, Kranz, etc.) and even to-day after thirty years this greatest riddle of German geology is still the centre of exciting discussions. Nevertheless if the theories have changed the fundamental work was done by Branca.

In palaeontology his main work was on the development of the Ammonites, on fossil fish and the origin of man. He organized the great Tendaguru Expedition to former German East Africa, the results of which are now to be seen at the Natural History Museum of Berlin and remain an indissoluble monument to this great geologist.

HERBERT P. T. ROHLEDER.

CORRESPONDENCE.

TO ALL THOSE INTERESTED IN ECONOMIC GEOLOGY.

SIR,—This is an earnest appeal for help towards establishing an Annotated Bibliography of the International Literature of Economic Geology.

No country is sufficient unto itself and least of all in science. All geologists probably realize this ; and those who employ geologists should likewise realize that the efficiency of their staff is largely dependent upon familiarity with the progress of science throughout the world. We can not afford isolation or imperfect knowledge. A plan worked out by the Division of Geology and Geography of the National Research Council at Washington for such an Annotated International Bibliography has been approved by the Council itself, the U.S. Geological Survey, the U.S. Bureau of Mines, the American Institute of Mining and Metallurgical Engineers, and the Society of Economic Geologists.

The plan includes a subscription fund of at least $18,000, which will provide means for the editorial work for from five to seven years. The National Research Council has agreed to serve as treasurer and custodian of these funds, to be expended in accordance with the usual customs of the Council. Tentative arrangements have been made with an experienced bibliographer to take charge of the work. The Economic Geology Publishing Company has agreed to publish the bibliography, which is to be issued in two volumes per year, aggregating about 400 pages, and to sell it for an equitable price, which will probably be about $2.50 per volume, which should pay for paper, printing, and distribution.

It will be observed that the present plan is restricted to economic geology and calls for funds to carry on the work for a limited time only, but it is felt that it will prove so useful, indeed, so indispensable, that little difficulty will be experienced in providing for its indefinite continuation. The subjects to be covered include articles on all metallic and non-metallic deposits (including petroleum and gas), hydrology, engineering geology and soils (in so far as related to geology). Publications in other branches of geology will be included if they have any bearing on economic geology.

Subscriptions will not be called for until the amount deemed necessary has been subscribed. Pledges should be sent to Professor W. Lindgren, National Research Council, Washington, D.C., U.S.A.

W. Lindgren.
E. De Golyer.
G. F. Loughlin.
W. C. Mendenhall.
R. A. F. Penrose, jun.

ANNOUNCEMENTS AND INQUIRIES.

In unofficial connection with the meetings of Section C (Geology) of the British Association for the Advancement of Science at Glasgow, 5th to 12th September, it is proposed to run two long excursions. One, preceding the meeting, is to be held from 30th August to 4th September (approximately), and is to be conducted by the President, Mr. E. B. Bailey, B.A. From Ballachulish, as centre, the recumbent folds and slides of Ballachulish, the cauldron subsidences of Glen Coe and Ben Nevis, and the parallel roads of Glen Roy, will be inspected.

An excursion to Arran from 12th to 19th September (approximately) after the meeting will be conducted by Dr. G. W. Tyrrell. Amongst the phenomena to be seen in this classic island are the tectonics of the Northern Granite, Hutton's unconformity, the U-valleys of Glen Rosa and Glen Sannox, the Arenig (?) pillow lavas and cherts of North Glen Sannox, the Central Ring Complex and hybrid rocks, composite sills and dykes of Tormore, Bennan, etc., the Arran Dyke Swarm, etc.

Owing to the difficulty of securing accommodation the parties must be limited to from 20 to 25 persons. It is hoped that foreign guests will attend. In order that arrangements may be made in good time, those desirous of attending these excursions are requested to notify Dr. G. W. Tyrrell, University of Glasgow, as soon as possible.